ELECTRICAL ENGINEERING

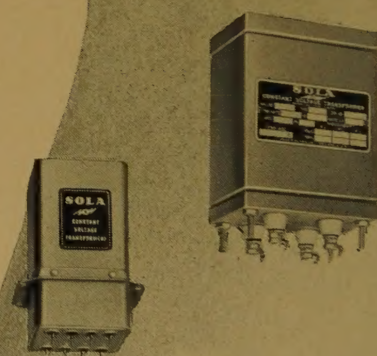
Illinois U Library

OCTOBER 1946

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Constant Voltage

Let a SOLA CONSTANT VOLTAGE TRANSFORMER insure the claims made for your equipment



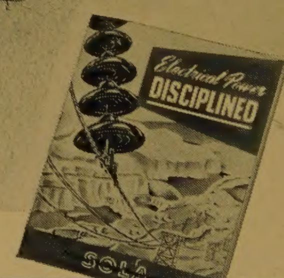
● When you establish the performance standards for your equipment—are you taking into consideration the fact that line voltages in the field will vary as much as ± 15% from the nominal value specified on your label?

These voltage variations are *your* problem. Your equipment must work properly in spite of them.

You can build voltage variations out of your equipment by building SOLA Constant Voltage Transformers INTO it. These transformers will absorb line voltage variations as wide as 30%, while maintaining rated voltage to your equipment.

Many manufacturers have built this protection into their product at an actual saving, both in original cost and maintenance. Consultation with SOLA Engineers may show you the way to similar savings.

SOLA Constant Voltage Transformers are available in capacities from 1 VA to 15 KVA. Many standard designs are available from stock. If standard units are not suited to your requirements, special transformers can be designed to your specifications.



IMPORTANT READING

for every designer, manufacturer, salesman and user of electrical or electronic equipment.

Ask for Bulletin ACV-102

SOLA *Constant Voltage* TRANSFORMERS

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • etc. **SOLA ELECTRIC COMPANY, 2525 Clybourn Avenue, Chicago 14, Illinois**

Manufactured in Canada under license by FERRANTI ELECTRIC LIMITED, Toronto

David C. Prince—Lamme Medalist

The 18th annual presentation of the Lamme Medal took place at the recent AIEE summer convention in Detroit, Mich. The 1945 medal was awarded to David C. Prince (F '26) "for his distinguished work in the development of high voltage switching equipment and electronic converters." The award is made each year to an engineer "who has shown meritorious achievement in the development of electrical apparatus or machinery."

Photo courtesy Electrical Contracting

AIEE President William C. Wickenden (F '33) (left) presents the Lamme Medal to Past-President David C. Prince (F '26)

The Lamme Medal

C. M. LAFFOON
FELLOW AIEE

THE FIRST LAMME MEDAL Award was made in 1928 and similar annual awards have been made since that time. The medal award ceremony this year thus was for the 18th recipient of this outstanding honor.

In previous years the biography of the donor, the conditions and circumstances associated with the provisions for the award, and the terms of the award have been presented by others in considerable detail, and so need not be repeated here. It, however, seems appropriate to add, if not to repeat, the fact that Mr. Lamme was fundamentally a design and development engineer throughout his entire engineering career. His heart and soul were wrapped up completely in electrical engineering design problems. He was not interested in the executive phase of engineering and did not function in that capacity as chief engineer of the Westinghouse Electric Corporation.

He felt very strongly that design engineers needed, not only encouragement and inspiration, but also recognition by the engineering profession for outstanding ability and achievement. It was primarily for this reason that the bequest for this medal award was made.

There are many conditions associated with, and characteristics of, Benjamin G. Lamme, the man, that are unusual and interesting. He was a firm believer in the theory that a person's inherent aptitude for a particular type of engineering work would manifest itself at an early age. If one, during childhood, enjoyed finding ways and means of building toys and structural things he had the earmarks of a designer. On the other hand, if he liked most to make things run or perform, he had natural instincts toward application or operating engineering. This working theory was used by him for many years in selecting candidates from engineering college graduates for special design training. He never was disturbed by the fact that an occasional design school candidate would misrepresent his early aptitudes; for invariably the truth would be self-revealed and the person finally directed to some more suitable activity.

The imagination and enthusiasm so strongly associated with Mr. Lamme's engineering work were also evident in his outside activities. He had an intense passion for reading weird and imaginative fiction for relaxation purposes. An around-the-world trip was made to see and examine at close hand the famous historical buildings and structures in Africa, Asia, and Europe. As a personal pleasure he particularly enjoyed owning and driving high-powered reliable cars at rather high speeds.

C. M. Laffoon is manager, a-c generator engineering department, Westinghouse Electric Corporation, East Pittsburgh, Pa.

An address delivered during the Lamme Medal presentation ceremony at the AIEE summer convention, Detroit, Mich., June 24–28, 1946.

As might be anticipated from one so completely devoted to his engineering work, Mr. Lamme never was married. On a number of occasions he, half-jokingly, and possibly in self-defense, remarked that an engineer did not have time to be an engineer and to carry on the responsibilities of a family. Although Mr. Lamme was always friendly and extremely considerate of people, he maintained close social contacts with only a very small number of persons. He took great delight in unobtrusively discussing engineering problems with, and thus obtaining the viewpoint of, the nontechnical people with whom he occasionally came in contact.

As time moves on it is to be expected that many of the events, facts, and conditions connected with Mr. Lamme's life will assume different significance, and his engineering contributions greater importance. In the Lamme Medal presentation we not only bestow recognition on one of our own present outstanding engineers, but also pay our respects, tribute, and honor to the memory of one of our truly great pioneer engineers.

The Medalist's Career

H. E. STRANG
FELLOW AIEE

The 1945 Lamme Medalist, David C. Prince, is first and foremost an inventer with 93 patents to his credit covering subjects ranging from electric ship propulsion to welding circuits. A consistent breaker of tradition, he is one of those who have the ability and imagination to think in terms of progress in broad steps regardless of the seeming insurmountability of the problems confronting them. He is considered an ideal choice for the medal which symbolizes the engineer's hopeful attitude toward the seemingly unattainable.

IF WE COULD look back on a scene in Springfield, Ill., on a day early in this century, we might see Doctor Prince, a successful surgeon, and his son David going about in a single cylinder Oldsmobile as the doctor made his calls. The boy was as full of questions as most normal youngsters of that age. In response to the searching "Why is this so?" he got not only specific answers from his father, who was an inventer in his own field, but also encouragement to extend his thinking and questioning along new and unexplored lines. Through this association was built the foundation for new and creative thinking which characterizes David Chandler Prince and which has led to the high honor of the award of the Lamme Medal.

It was quite natural for Doctor Prince to hope that David would follow in his footsteps in the medical field, and so, after graduation from the Springfield High School in 1908, David entered the premedical course at the University of Michigan. After a year and a half of this course, during which time he had been studying engineering just as a hobby, he persuaded his father that engineering, and not medicine, was really his proper field. The next year David transferred to the University of Illinois so that he might spend his last two undergraduate years studying under Doctor E. J. Berg, professor of electrical engineering, and former assistant to Doctor Steinmetz in the General Electric Company. David then was certain that he was on the right track. Doctor Berg thought so, too, and years later said of him, "I never knew anyone else who had the keenness of mind and understanding of Prince."

Following graduation, and at Doctor Berg's suggestion, Prince obtained a summer job in the General Electric Company's service shop in Chicago to round out his technical training with some practical field experience. He then returned to the university for a master-of-science degree, and, with this to his credit, set out for Schenectady, N. Y. After a typical experience on "test," mostly spent working on motors and generators, Prince acquired an ambition to become associated with Doctor E. F. W. Alexanderson in the transportation engineering department. The first World War soon interfered, however, and shortly after the United States entered, Prince enlisted and was shipped overseas as a first lieutenant in the United States Army Ordnance Department. His two years in France were, from his standpoint, educational and enjoyable. Attached to the air service, he was given the task of installing guns on airplanes purchased by the United States from the French, and even though he occasionally had to go "AWOL" to do it, he completed the task. For this work he received from Washington, at the close of his military career, a citation "for especially meritorious service in the solution of engineering problems relating to aircraft." He still keeps on his desk, as a paperweight, a jagged chunk of metal from a Big Bertha shell which landed not far from him on a street in Paris.

After the war, Prince returned to Schenectady just in time to hear that a patent had been granted on "certain new and useful improvements in speed control of induction motors." This was his first patented invention—the product of his earlier work with Doctor Alexanderson, whose name also appears on the patent. As he resumed work—first with Alexanderson, next in the radio engineering department, then on a part-time job

---

H. E. Strang is staff assistant to manager of engineering, apparatus department, General Electric Company, Schenectady, N. Y.

An address delivered during the Lamme Medal presentation ceremony at the AIEE summer convention, Detroit, Mich., June 24–28, 1946.

with Alexanderson in the new Radio Corporation of America—he literally began to pour out inventions. At the present time, his patent score stands at 93. These cover an amazing range of subjects—electric ship propulsion, a-c locomotives, circuit breakers, protective relays, welding circuits, vacuum switches.

Many men, both within and outside the General Electric Company, have more patents to their credit than Prince. Few, however, have worked out so many usable ideas. His fundamental improvements in electronic tube circuit control have broadened the scope of resistance welding and thus directly improved mass production of refrigerators, railway cars, and airplanes.

Prince worked with Alexanderson until 1923 when he was transferred to the research laboratory. He spent months in the study of electronic theory, which at that time was a new subject on which very little was written, and was busy for several years on vacuum tube application. He was selected by Doctor Whitney, head of the research laboratory, to attend an AIEE meeting in Salt Lake City in 1926 principally to hear a paper being presented by Doctor Sorensen on vacuum switches. Later, when Doctor Sorensen brought some of these switches to Schenectady to be tested in the switchgear short-circuit testing station, Prince was selected to assist. This was his first intimate contact with switchgear, and between tests on the vacuum switches, he inspected and asked lots of questions about the oil circuit breakers which he saw around the station. This interest continued and in 1929 he was appointed research engineer of the switchgear department.

Prince came to the switchgear organization with a complete lack of knowledge of the things which could not be done. Circuit breakers had been improved continuously over the period of the previous ten years. They had not reached a state of perfection, but generally were conceded to be highly developed. It was the general impression of those connected with this business, for instance, that it was folly to think of building a high voltage oil circuit breaker with less than one-tenth of the amount of oil contained in conventional breakers, or one which would interrupt a short circuit in one-sixth of the time of the good breakers of that day, or one in which porcelain would replace good heavy thick steel. Prince did not share in this impression, but proceeded to develop such a breaker and to design many other important, but possibly less spectacular, things. He did them because he had the imagination and courage to think and plan for progress not by small increments, but by bold, broad steps.

Lamme Medalists

1928	Allan Bertram Field	1937	Robert E. Doherty
1929	Rudolf E. Hellmund	1938	Marion A. Savage
1930	William J. Foster	1939	Norman W. Storer
1931	Guiseppe Faccioli	1940	Comfort A. Adams
1932	Edward Weston	1941	Forrest E. Ricketts
1933	Lewis B. Stillwell	1942	Joseph Slepian
1934	Henry E. Warren	1943	A. H. Kehoe
1935	Vannevar Bush	1944	S. H. Mortensen
1936	Frank Conrad	1945	David C. Prince

Not all of the ideas which he developed so successfully were original with him. One of his first moves after joining the switchgear department was to study the patent file. There he uncovered a patent on the oil-blast arc-control device in the interrupting structure of oil circuit breakers which had been left dormant for a number of years. He continued the development of this principle, and brought it to a successful conclusion so that it was of major importance not only in new lines of circuit breakers then being built, but possibly more important, in its successful application to many breakers already in the field to provide them with the benefits of modern performance and to ward off obsolescence.

His major achievement in this field was the development of the entirely new low-oil-content impulse-type circuit breaker for the 287,000-volt Boulder Dam line. Up to that time, breakers had been built which would operate in eight cycles, but the requirements for this transmission line demanded 3-cycle operation, and at a higher voltage than any breakers ever built. Two of the stations requiring these breakers were in isolated locations in the desert where oil handling facilities would be dictated solely by the requirements for the circuit breakers, there being no other apparatus using oil. Prince had done some work with lower voltage breakers employing a mechanically operated piston to force oil across a pair of contacts to bring about prompt and consistent operation at 11,000 volts. This principle was adapted easily to a mechanical arrangement which used only a fraction of the oil found in conventional large tank-type circuit breakers. The oil was used for interruption only and not for insulation to ground. He reasoned that if he could put enough of these breaks in series, and could get them to share the duty, the principle could be extended to the higher voltages.

His first crude sample, using eight breaks across which oil was forced by the action of a single piston, was made from pipe fittings and other odd bits and pieces readily available. It looked like nothing that ever had been seen before in the circuit breaker field, but it worked. Many of the multitude of mechanical design problems incident to translating the principle embodied in this first sample into a finished product were solved by characteristic bold departure from customary practice. The success of this venture, which might be considered symbolic of the principle of breaking with tradition, may be judged best by the fact that the first circuit breakers of this type have completed ten years of successful service. More were placed in service later for these same lines, while others for lower voltages have found application

in other parts of the United States and Europe when their particular features appeared best adapted for a specific application.

It is particularly significant to note evidence that Prince's spirit of invention is contagious. While he was busy bringing forth ideas about many other types of circuit breakers and accessories, which there is not space to chronicle here, he was successful in inspiring others to do likewise. The number of new ideas submitted to the patent department of the General Electric Company from the switchgear engineers showed an appreciable upward trend after Prince joined the organization.

In 1940 Prince was brought back to Schenectady and named manager of commercial engineering for the apparatus department. Eighteen months later he was elected vice-president. In this executive capacity he still finds outlet for his inventive ability. For many years he has been a student of economics although he modestly insists that Mrs. Prince is responsible for inspiring most of his activity. In developing some of his ideas along this line, he prevailed upon Charles E. Wilson to speak at the 1941 AIEE winter convention, Philadelphia, Pa., on "The Challenge to Private Enterprise" (*Electrical Engineering*, March 1941, pages 99–104).

Later, while the National Defense Program and the War Projects Committee, of which he was a member, were taking most of his time, he was named chairman of a special planning committee in the company. This group was organized to formulate general plans for the postwar reconversion in order to save time in the reemployment and the return to peacetime production. At the same time, Prince was a member of the National Committee for Economic Development.

As president of the AIEE (1941–42), he visited many Sections, inspiring engineers to think ahead, not only in terms of the future of their specific assignments, but also in broad terms of the help which they might be as a group in the national postwar economy. In recognition of this activity, Prince was awarded an honorary degree of doctor of science in 1943 by Union College.

Early in 1945 Prince was placed in charge of the combined general engineering and consulting laboratories which serve the whole company. In this capacity, he finds an outlet for his skill and aggressiveness in the development field, and is engaged in many activities which he sincerely believes will make the world of tomorrow a better place in which to live.

Prince is firmly convinced, and in practice has carried out the idea, that a real inventer can find himself at home in any field. He maintains that inventive and thinking engineers can have an important voice in shaping the economic and political future of the United States as well as in its progress in material things.

The Lamme Medal committee truly was inspired in selecting David C. Prince as the recipient of the medal on which is engraved—"The engineer views hopefully the hitherto unattainable."

The Lamme Medal Inscription

DAVID C. PRINCE
FELLOW AIEE

The engineer's hopeful attitude toward the hitherto unattainable has been justified by his accomplishment, time and again, of the seemingly impossible. Inasmuch as he is able to achieve such gratifying results in his own field, perhaps his methods could be applied with equal success in the wider field of human relations.

"THE engineer views hopefully the hitherto unattainable." The inscription on the Lamme Medal long has been an inspiration to me as I am sure it has been to a great many other engineers.

The engineer grasps at the seemingly unattainable, fails, and optimistically tries again, and the records prove

---

David C. Prince is vice-president in charge of application engineering, apparatus department, General Electric Company, Schenectady, N. Y.

Essential substance of an address delivered during the Lamme Medal presentation ceremony at the AIEE summer convention, Detroit, Mich., June 24–28, 1946.

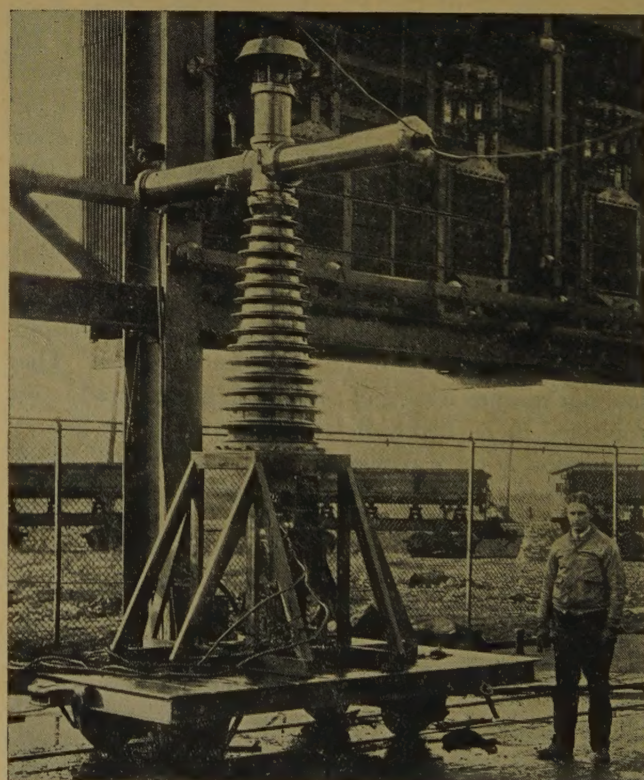


Figure 1. 220-kv oil-blast circuit breaker constructed from pipe fittings

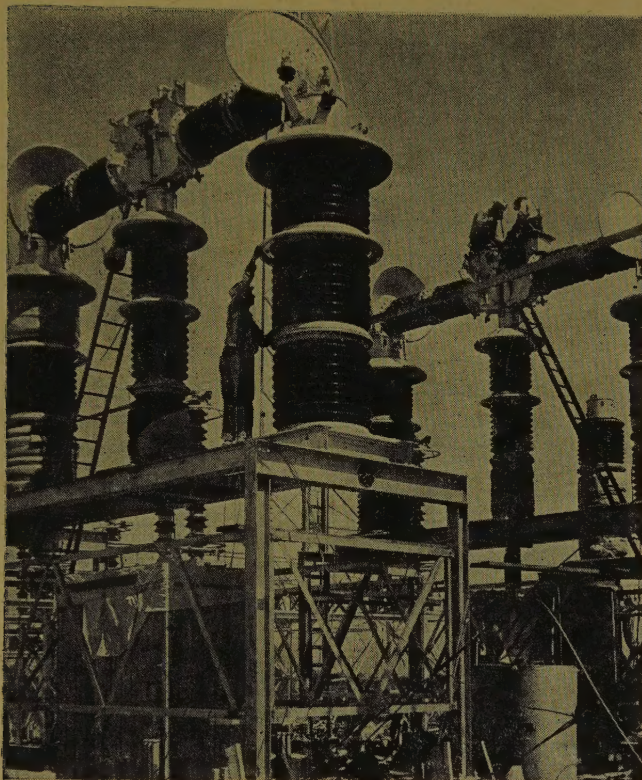


Figure 2. Boulder Dam circuit breaker, successor to circuit breaker shown in Figure 1

that he is justified fully in doing so for he has gone on to achieve, time after time, what once was thought impossible. In my own experience, for instance, a lot of things have been accomplished which, at one time, were just vague hopes that many people did not share. As an example, Figure 1 shows a collection of pipe fittings, the first sample of the circuit breakers which later were built for Boulder Dam. At the time the equipment was assembled anyone who regarded it as a circuit breaker was not taken very seriously. However, when you think in terms of fundamentals, you realize that, after all, a switch really does not do any work. It merely carries currents when it is closed, in which capacity it is about as effective as a straight piece of copper wire, and it prevents the flow of current when it is open, at

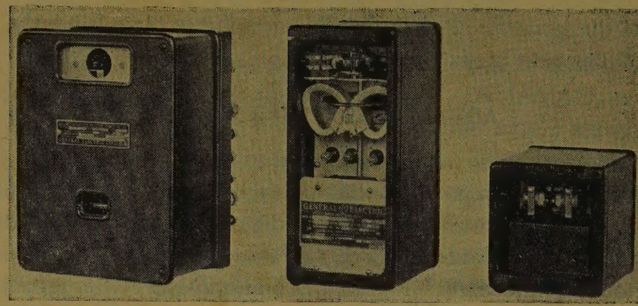


Figure 3. Polyphase directional relays (General Electric)

Right-side oblique front view showing comparative size. Left, 1931; middle, 1932; right, 1937

which point it is doing approximately the job of a good insulator. Thus, the ideal circuit breaker simply should be an insulator with some means of rendering it conducting or nonconducting and that, if you discount the traditional view, is exactly what the pipe fitting collection was.

Figure 2 shows what this circuit breaker eventually became. (It later was moved out into the desert between Boulder Dam and Los Angeles, Calif.) This idea, of course, is only one example of the engineer's hopeful attitude toward progress. This type of progress is not limited at all to those devices which really have no work to do, but is characteristic of many lines of activity.

THE RELAY

Advance in another field, relays, is illustrated in Figure 3. In 1921 we started with a large relay which was both slow and inaccurate. We then reduced the size. We attained the "unattainable" in 1932, and took still another cut out of it in 1937, so we know on the basis of past experience, that, having attained the unattainable in any given year, we may expect with equal hopefulness to attain it again, even in the same line, six years later.

A new gain often is made possible by other previous gains, such as in the case of metalclad switchgear (Figure 4), and each one of these gains was made possible by other gains that occurred in some auxiliary apparatus. Thus, as the snowball rolls, each time we discover something new and attain some new "unattainable" thing, each discovery gives us new vision so that we can view other unattainable heights with hope for realization in the future. These discoveries are not limited, of course, to switchgear either. From 1930 to 1934 the volume of one line of static capacitors was reduced in three stages to approximately 25 per cent of the volume at the beginning

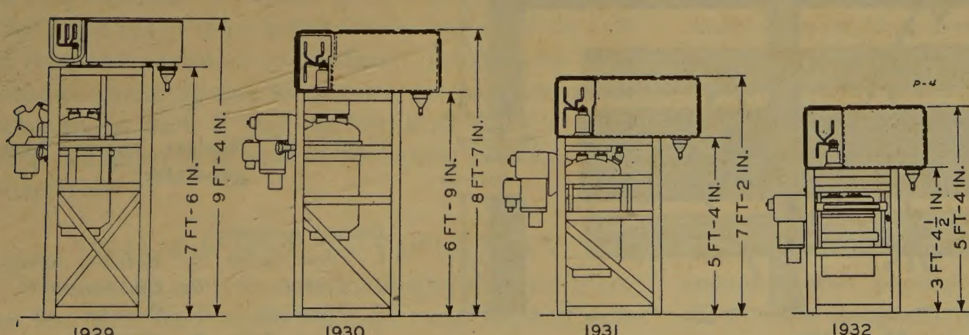


Figure 4. Progressive development of indoor metalclad switchgear

of the period. Power transformers have shrunk nearly 50 per cent in size and weight.

ADVANCE IN OTHER FIELDS

Nor are these advances limited to apparatus like transformers and capacitors which deal only with electricity. The motor, standby for making the conversion from electricity to mechanical power, also shows a record of continuous advancement. (Figure 5.) Not only has this progress been made year after year in one of the oldest of electrical tools, but the advances continue nearly unabated without any sign of tapering off. Here we have the record, the proof of why the enginer now, just as in Lamme's time, can view the hitherto unattainable hopefully. The automotive people have made continuous progress in automotive vehicles; the airplane people have made continuous progress; the chemical engineers have made continuous progress in their medium; and the electrical engineer is accelerating the rate of that progress.

The process of evolution is not limited to the engineering profession. The medical profession certainly has accomplished outstanding improvements in its activities thus far, and there is no reason why anybody should expect a lack of progress or an end to the continuous improvement of conditions.

UNIVERSAL PROBLEMS

Under such circumstances, why is it that there are so many people who are without hope; who are in despair at the present time? They look about them despairingly, they see the chaotic conditions of the world and everything looks black. They seem to feel that optimism may be justified in engineering matters but, for the world at large, hope must be abandoned. They particularly feel this despair in the face of demands for full employment and a high standard of living, and in the all-important desire for world peace. They feel that we are helpless; that mechanical tools and technical tools abandon us to our fate when we approach those subjects which are not regarded as definitely within the field of the engineer.

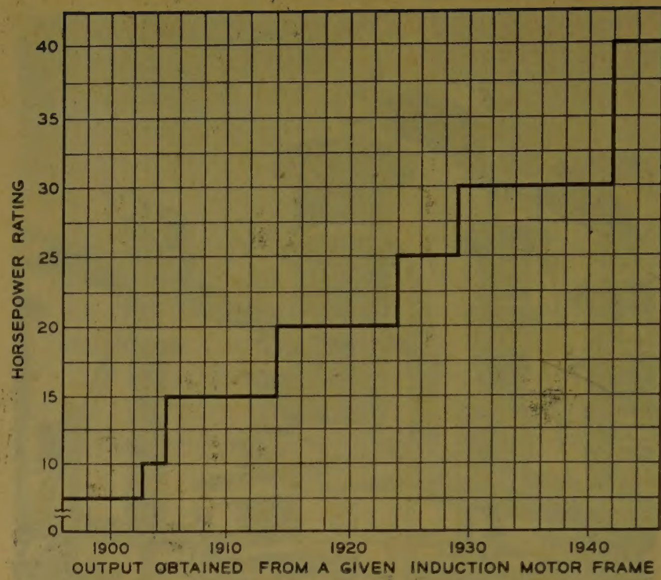


Figure 5. Output obtained from a given induction motor frame

That is not necessarily true. There is no reason why the engineer should be helpless in the face of these more universal problems. Perhaps we should analyze the situation a little and see what the characteristics of the unattainable are, this unattainable that is viewed hopefully by the engineer. A rather definite line goes through engineering science which many people have overlooked and that is the line which depends on whether we are viewing the science as an operational matter or observational matter. When an astronomer views the stars, he knows perfectly well that any kind of observation he may make will not alter in any manner the progress of the stars or their movements. The same applies to a man who is going to view a minute electric

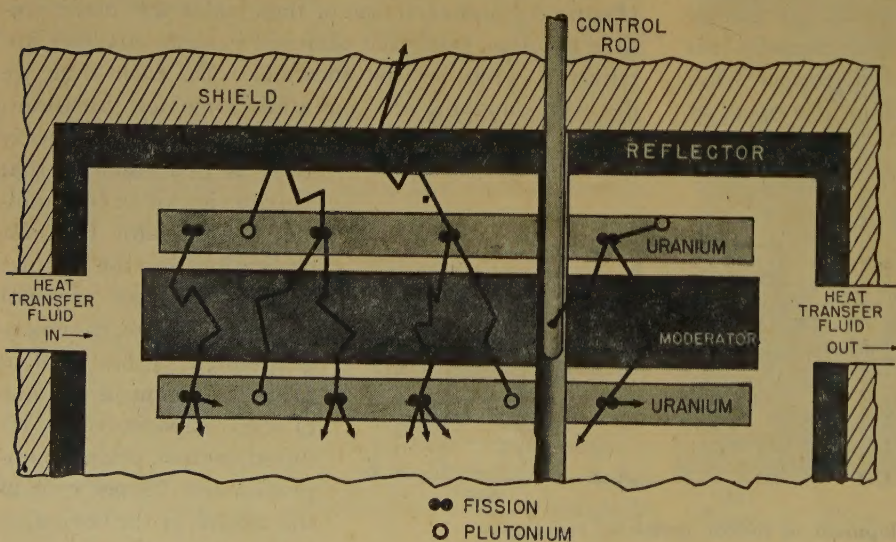


Figure 6. Nuclear energy heat generator

Research problems:
1. *Chain reaction*
2. *Control*
3. *Plutonium*
4. *Poison effects*
5. *Radiation stability*
6. *Heat transfer*
7. *Corrosion*
8. *Shielding*
9. *Size*

current. If he does his work well, he must measure that electric current so that nothing which he does will alter the amount of that electric current, otherwise he has failed in his scientific job of accurate observation, and, as long as we think of science in terms of accurate observation, the ideal is not to make things better, but to repeat the truth with the absolute maximum of accuracy. I think, in general, we will find, when we get into those fields where little progress has been made, that the approach has been an observational approach. The objective has been a search for truth, not the attainment of the hitherto unattainable.

If this is a true estimate of the situation, then what must be done is for the engineer to move over into those fields whose heights have been monopolized by the observational scientists and to bring to bear the operational point of view as represented by these cases where the impossible has been approached and realized, at least partially, again and again.

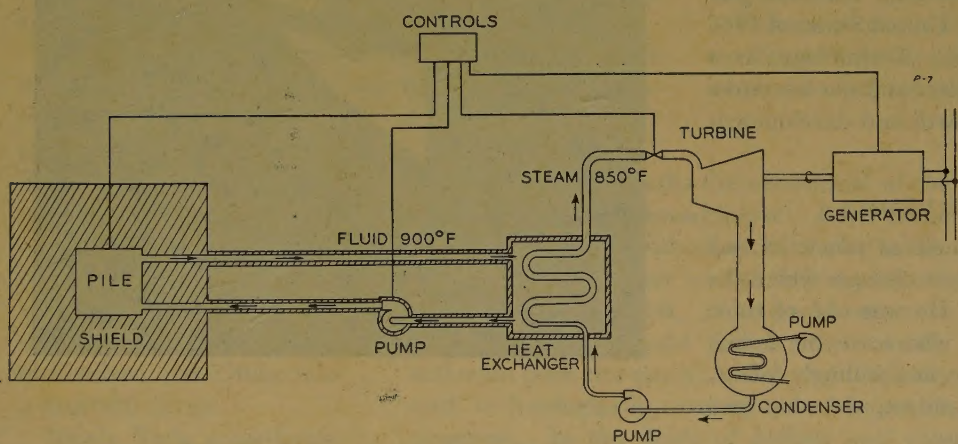


Figure 7. Diagram of fluid convection transfer systems

With particular respect to economic matters and the desire for high levels of production and employment, there are certain technical things which were developed during the war that the engineer can offer and which will be of immeasurable help in that area of endeavor. For example, the development of mechanical machines which perform mathematical operations with great speed and in that way make it possible to do a great many things that could not be done before simply because of the lack of time and personnel to do them. By applying these tools we should be able to measure the operation of our economy in such a way that we shall know at once what is happening in time for something practical to be done about it.

NUCLEAR ENERGY AND WORLD PEACE

When we go on to consider the matter of world peace we find that there again we have some startling new engineering tools coming to our aid.

Figure 6 shows, in diagrammatic form, what a nuclear pile is like.

A pile is the instrument or apparatus that is used to develop power from nuclear energy. In the chain-reacting pile uranium may be used as the active agent with a moderator that slows the neutrons down, and the fissionable material, plutonium, is produced. In the the operation of fissions, of either the uranium or plutonium, heat is produced which may be utilized for the development of power.

Figure 7 illustrates diagrammatically how the power may be obtained and employed. It is necessary to have a circulating medium going into the fission unit shown in partial diagram in Figure 6, because there are great volumes of radiation which are rather unhealthy for anyone in proximity. We then get heat from heat transfer units and produce steam which can operate any standard turbine either for the use of an electric generating plant or directly, as in the diagram, to give the propellers of a ship the necessary power.

What might one expect to accomplish by such a device? A modern destroyer driven by nuclear power could go a million miles at 35 knots on just 15 tons of fuel. That is just one indication of the tremendous developments possible and it should show anyone beyond a doubt that isolationism no longer exists in this world. It just is not possible any more and so we must view hopefully, if we are to do it at all, a future in which we are going to be dealing with far larger powers than ever have been available to man before.

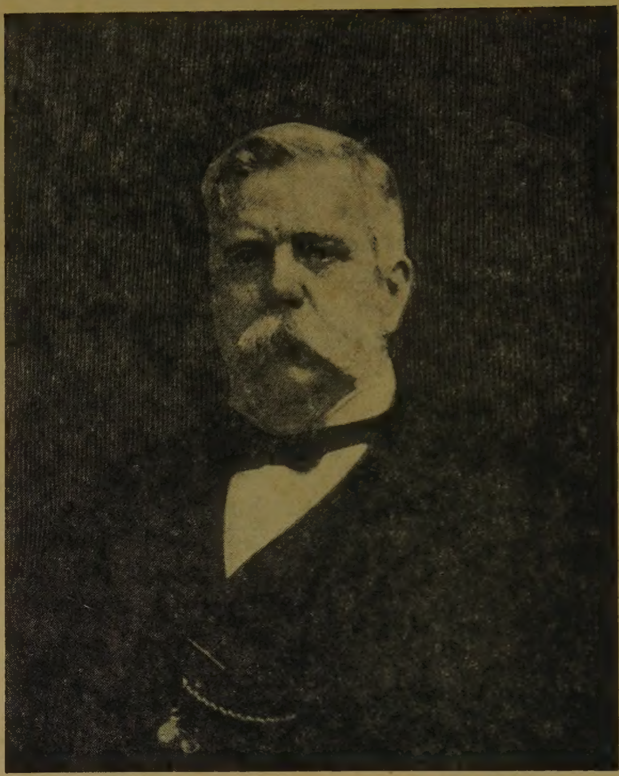
I am not able to say, of course, even if I knew, how this powerful new tool that is being handed over to the engineers is going to be used to bring about world peace, but it is evident that those who understand how a tool of this type works are going to play a necessary part in deciding how it will be employed and in making the American people realize what it means to have this amazing resource at our disposal. At the present we probably can do nothing more valuable than support the Baruch Report, because there is no question but that international control of atomic energy is necessary if it is to be the power for good that we all want to make it rather than have it, like Frankenstein's monster, destroy those who conceived it. So we turn back then to Mr. Lamme and his simple expression of opinion, "The engineer views hopefully the hitherto unattainable." All of these things are attainable to the engineer who views the future hopefully and does something about it.

George Westinghouse—Individualist

J. K. B. HARE

GEORGE WESTINGHOUSE was born in 1846—exactly 100 years ago. At that time, the United States west of the Mississippi was largely Indian territory; or Oregon country disputed between the United States and Great Britain; or what is now California, but was then a part of Mexico—a nation with which the United States was about to engage in war over the annexation of Texas. James Polk was in the White House; and emigrations were under way to California and Oregon, with the Mormons moving West.

Technological progress was stirring, though feebly. The first telegraph line was in service between Baltimore and Washington, and the Pennsylvania Railroad just was being established. Life in the United States of 1846 was rugged, and living was hard. Technology, as a word, did not exist in the dictionary, and our ancestors were not concerned about the growth and development of large corporations.



WESTINGHOUSE; THE LEADER

George Westinghouse contributed as much as any man in the past 100 years to the vast changes which the United States has encountered. He was one of those few creative geniuses of all time who serve the many, one of those on whom the rest lean and willingly follow. As followers, we only can perfect and expand what men of his caliber conceive and originate.

There was no mistaking the character of George Westinghouse. As a small boy, I grew up within a few blocks of his home. I saw him daily, and he looked the part of and spoke as a leader.

George Westinghouse was granted his first patent in 1865, when he was 19 years old (the year the Civil War ended) and he died 49 years later. His active engineering and business life thus was spent during two major wars; during a period of rapid industrial progress, when the spirit of the times and the thinking of the people were favorable to the development of giants.

In this anniversary year American industry acknowledges the engineering and industrial achievements of one of its giants, and so I wish to remind the reader of his contributions to the development and growth of the electrical arts. However, I also wish to pay tribute to the man, George Westinghouse, pioneer and individualist, and to point out the changes in spirit that have occurred within the generation that has grown up in the 32 years since his death.

Very recently, the city of Pittsburgh went through an experience which focused sharp attention on both of these subjects. The strike of the employees of the Duquesne Light Company stopped the transportation system, shut down industries not already idle because of the steel and electrical industry strikes, vacated schools and theaters, and killed practically all of the varied activities of a modern city, except those absolutely essential to health, public safety, and life itself.

The strike was only one evidence of the deep changes in social, labor, political, and industrial thinking that have occurred since George Westinghouse's death. The vital importance of the electrical industry to daily life was brought home to Pittsburghers with real suddenness and stark reality. Householders realized, possibly for the first time, that, in addition to its obvious uses for light, cooking, and domestic tasks, electricity was required to keep home-heating furnaces in operation; to keep food from spoiling in homes and stores; to process the daily milk supply; and to bring news into the home by newspaper and radio.

Essential substance of a paper presented at the AIEE summer convention, Detroit, Mich., June 24–28, 1946.

J. K. B. Hare is vice-president, Westinghouse Electric Corporation, Pittsburgh, Pa.

INDUSTRIAL CONTRIBUTIONS

The electrical industry, which was truly an infant when George Westinghouse first became interested 60 years ago, has grown into an indispensable part of the daily living of every person. It is a valued servant, but, together with other features of modern living, it has made us absolutely dependent upon reasonable co-operation and a decent regard for the rights of each other, and of the public, in our social organization.

In the railroad field, George Westinghouse made his contributions in the air brake, draft gear, and railway signaling. In the electrical field, he made his contribution indirectly through the engineering and commercial development of other men's inventions. His was the imagination, the energy, the ability to see the value in other men's ideas, to make them useful in forms of steel and copper, and to promote and sell them to an amazed and sometimes bewildered public.

Undoubtedly the greatest contribution of George Westinghouse to the electrical industry was his development and active promotion of the a-c polyphase system.

Although he made mechanical contributions of his own, the polyphase system was the work of many inventers. The French engineer, Gaulard, and the Englishman, Gibbs, contributed the basic transformer; but Westinghouse (aided by William Stanley and Albert Schmid) redesigned the crude invention of Gaulard and Gibbs into a practical device.

Nicola Tesla contributed to the induction motor principle while Oliver Shallenberger used the same rotating field principle in his watt-hour meter.

It only adds to the stature of George Westinghouse that he could imagine the possibilities of these components as a complete power system, and could bring together men of such varied talents and characteristics in a co-operative team; that he could organize and staff his companies, and thereby multiply his own great talent and power. His courage and resourcefulness were demonstrated in overcoming the technical problems and the somewhat hysterical public opposition to the supposedly greater hazards to life of high voltage alternating current.

He boldly accepted the contract to supply electric light and power for the Columbian Exposition, or World's Fair, at Chicago, Ill., before he had available a successful, noninfringing electric lamp, and when the Tesla induction motor barely had been born.

This year, 1946, marks the centennial of the birth of George Westinghouse. Born in an era of "rugged individualism," Westinghouse, himself, was a pioneer who contributed much to industrial advances. If he could return to earth today he would find a world vastly different from the one he knew. Scientifically and technologically, we have made much progress. In the fields of politics and economics, also, society has come a long way from the individualistic era of George Westinghouse, but it is highly debatable as to whether or not it has been in the right direction.

Soon after the successful opening of the Chicago World's Fair, George Westinghouse and his electrical manufacturing company undertook the construction of the 5,000-horsepower polyphase alternators for Niagara Falls. It is difficult for us, after 50 years of development, to appreciate the electrical and mechanical engineering problems involved; not only for the main generators, but for the circuit breakers, measuring and operating instruments necessary for the operation of a practical system.

George Westinghouse was responsible for bringing the Parsons steam turbine to the United States from England. Francis Hodgkinson and B. G. Lamme, Westinghouse engineers, were leaders in the development of the modern turbine generator unit. George Westinghouse acquired the McAlpin-Melville marine gear patents, and he was a pioneer in the application of economical high-speed turbines to ship propulsion. Again, through the work of Lamme and other Westinghouse engineers, his companies introduced the a-c railway system to this country.

There were giants in those days! And the climate and conditions were favorable for their growth and development. A railroad still was considered a community asset, and corporation officers were held to be respectable!

THE NEW GENERATION

What has happened to the United States during the generation since the death of George Westinghouse? What have we done with the heritage he and his contemporaries left us? If he could return to the scene of his work, and if his spirit could communicate his impressions to us, what would he say of our times and our work?

On the scientific and engineering side, he would find much to interest him, and I think he would be highly pleased. I imagine he would get busy immediately on the organization of a Westinghouse Atomic Power Corporation! He would be puzzled possibly, however, by the fact that the United States Government would not permit him to do any such thing.

In the social and economic fields, he would be pleased with high earned-wage rates and the vast improvement in factory working conditions. But he also would find much that would puzzle, if not amaze, him—much that he simply would not understand. And it is questionable whether we ourselves understand the problems with which we are confronted, because in our complex society, with its division of labor and its free exchange

of the products of labor, there are certain fundamentals without which our society cannot function.

Let us say it this way: There is a minimum of individual responsibility, a minimum of good will, a minimum quality of leadership below which we cannot go and still preserve a functioning society under complicated modern conditions. We have fallen, during the past few months, dangerously close to that minimum, if we actually have not gone below it.

Let us look at these three essentials: individual responsibility, good will, and leadership. What has happened to them since George Westinghouse lived among us some 30 years ago? And, more particularly, what has happened to them during the past dozen years?

INDIVIDUAL RESPONSIBILITY

Individual responsibility, resourcefulness, initiative, have been undermined by years of propaganda supporting government responsibility for jobs; for maintaining purchasing power; for increasing farm prices; for "holding the line" for all other prices; and for a Utopia of employment and permanent prosperity. I use the word "Utopia" advisedly, because every scheme for a planned society, from Plato's "Republic" to the Soviet Union, has required some form of dictatorship to run it.

During these years, Americans have moved a long way from the individualism of George Westinghouse, from faith and confidence of individuals in private enterprise, toward the planned economy of all-powerful government controls and subordination of purchasing power. I believe that Westinghouse was interested only in increasing earning power; and there is a vast difference between these two. It does not matter seriously how much we earn, if we earn it. There cannot be a sound economy in a state which tries to increase earning power by increasing purchasing power, as such. In other words, purchasing power that comes from earning power is always good; purchasing power that comes from any other source is suspect, and usually fails in its purpose.

To equalize earning power in the community, in the nation, throughout the world, is good because maximum trade will exist when all men are uniformly good customers, because of uniformly high earning power.

But equalizing purchasing power, except through individual earning power, is a Socialist delusion as many old and current experiments have demonstrated.

George Westinghouse, I am sure, believed in increasing and equalizing earning power. I am equally sure he would be bewildered and annoyed if one of the modern disciples of government-spending would maintain his purchasing power for him otherwise.

GOOD WILL

Good will between industrial leaders and employees, good will between business men and the public, has been destroyed systematically by government and by labor union propaganda.

Workers have been told that there are "hidden profits" and unnecessary reserves in "big business"; government agencies have circulated "confidential" reports (some later repudiated) to the effect that industry generally could pay higher wages if it "would put human values ahead of profits."

The people have been taught that profits are a social evil, that in some way, never explained, everyone could enjoy a life of abundance if only industry were not strangled by the profit motive.

It should not be necessary to explain that savings out of profits enable industry to increase its productivity and thereby increase real wages.

Strange as it may seem to radical reformers, liberal profits make higher wages possible. Real wages over the past 40 years, and, in fact, for centuries past, have increased almost directly with the investment per worker and the mechanical power available per worker.

The most capable and the most successful American corporations have been pilloried because of their success. The people have been taught, too effectively and dangerously, that industry in general is oppressive, is dishonest, and is the enemy of the common people. These words are strong, but they are not put too strongly to convey the fact that the labor-management problem today is one that requires the highest type of leadership in order to cement some measure of good will between these two essential factors, in the success of our economy, and in fact, of the United States as a nation.

LEADERSHIP

The third essential of a continuing society based on the division and specialization of labor, and the free exchange of goods, is the absolute necessity for at least a minimum quality of leadership at this time.

George Westinghouse and his contemporaries looked to leaders to guide material economy and he naturally and inevitably assumed his own large share of this responsibility. It has been popular since the "great depression" to belittle the quality and success of business leadership. This is one of the calculated results of the campaign of villification that has been pursued for a dozen years.

But, over the longer view, American business leadership has no reason to apologize for its record. Under this leadership, the United States has become, in spite of human shortcomings and failures, the most desirable place in this troubled world in which to live. During the past 12 years, this leadership of industry, and for our material well-being, gradually has shifted to Washington, D. C., and to the leaders of organized labor. After the experience of recent months, are we satisfied with the accomplishments of this new leadership?

One important factor which the leaders of our present economy have overlooked lies in the fact that industrial

leaders, at their very worst (and there have been some who were not too good) of self-seeking and abuse of power (and there were some abuses of power, as is well known), were producing and developing the United States; and, at the same time, they were increasing jobs and increasing income. They could advance their own interests mostly by increasing production, and so they could not help being on the side of production.

But political leaders, and labor leaders, at their best can hardly help industry to produce. They do not contribute directly to the production of wealth; their major purpose is to redistribute wealth. At their worst, and we have seen some of it during the past few months, political and labor leaders get in the way of production, and jobs, and better living.

George Westinghouse lived his active life, and did his work, in a world that took private enterprise for granted. His times were still close enough to the European planned economies of the 18th century from which Americans escaped, by the determination and wisdom of the fathers of the republic of the United States. These fathers, and the generation of Westinghouse, knew and feared the all-powerful government that planned economy requires. They valued the individual freedom that must be paid for by individual responsibility, sometimes by dangerous insecurity.

George Westinghouse, for one, was no timid advocate of security, and paid the full penalty for the lack of it in the year 1907. At that time, painting with a wide brush and with a boldness which was one of his characteristics, he found himself overextended and lacking the necessary funds with which to carry on those many ventures which he had conceived and which were then in the mill. Bankers were necessary; and it is to be noted that they did a constructive job in assisting the Westinghouse Electric Company again to walk alone.

It was not the first time that Westinghouse had been out of money; but the aftermath of this meant his physical separation from the company which he had founded, and to which he had contributed so much.

If George Westinghouse could communicate with us today, I am sure he would tell us that the real reactionaries are those who would have us go back to the government-planned economy and the state-monopolies of a century and a half ago. He would tell us that peacetime growth and progress come most fruitfully from individual liberty, from the release of individual genius such as he himself displayed.

One of the major fallacies of state-planned economy is that growth can be planned. The development of an idea, an invention, an industry, is unpredictable. Growth, or stagnation, is in the hands of our leaders!

George Westinghouse—engineer, organizer, pioneer, individualist, great American—surely would approve of that fact if he were alive today.

The Engineer and the Union

HOWARD D. BURNS
STUDENT MEMBER AIEE

COLLECTIVE BARGAINING, as carried on by labor unions with employers, has two principal aspects. In the first place, it is a method of price-making—making the price of labor. In the second place, it is a method of introducing civil rights into industry, that is, of requiring that management be conducted by rule rather than by arbitrary decision. In this latter aspect, collective bargaining becomes a method of building up a system of "industrial jurisprudence."

Wage earners have many specific purposes in seeking to build up a system of industrial jurisprudence. They wish to protect their organizations against being weakened by employers who might discriminate against union members; to strengthen their organizations by making union membership an aid to employment; to allocate limited opportunities to work; to make more

---

Essential substance of a paper presented at the Student Branch conference held during the AIEE Southern District meeting, Asheville, N. C., May 14–16, 1946.

Howard D. Burns is a student at the University of Alabama, University, Ala.

The author wishes to express his appreciation to O. W. Eshbach, dean, Northwestern University, Evanston, Ill., and vice-chairman of the AIEE committee on collective bargaining and related matters, for making available a selection of articles from his personal files as well as the AIEE report of the committee.

work for themselves; to protect themselves against the cost and impact of technological change.

UNION POLICIES

The system of industrial rights and duties which collective bargaining endeavors to establish deals with such matters as entrance to the trade, hiring, training, promotion, reduction of staff, technological change, and methods of compensation. The specific policies pursued by different unions and the rules which they seek to enforce differ greatly. The introduction of technological change into industry produces various policies. Some unions oppose technological changes; others seek to compete with new methods and new processes by making concessions on old methods; still others seek to control the introduction of new machinery and methods. Frequently, a combination of these several policies is pursued simultaneously. Various unions differ on policies regarding piecework or bonus systems. To some extent these variations in union policies and union rules are simply the result of differences in experience or differences in the intelligence and foresight of union leadership.

In a period of increasingly strong labor unions the engineer finds himself on the proverbial horns of a dilemma; whether or not, as a member of a profession, he would be benefitted by unionization. Because of the vital importance of such a decision to the many young men just entering the engineering field, and to the profession, *Electrical Engineering* presents the viewpoint of one of their number, a Student Member of the AIEE.

In human society, "labor" is no more a problem than are our professional groups of engineers and physicians. Labor cannot be solved like a problem in geometry. Labor and engineering are each continuing relationships, with changing emphasis—not problems which can be solved and then put out of the mind.

Of the many statements defining labor, capital, and organization of engineering, none ever has been so clear and vivid as the truism generally credited to Andrew Carnegie, "Industry is a three-legged stool, whose legs are capital, business (organization or management), and labor." Certainly only when these legs are kept of the same general length is the stool comfortable.

Unions continually must obtain increasing benefits for their members, else they fail. What labor and the public do not understand, however, is that the steady wage increases that have occurred in the past 50 years would have been utterly impossible had it not been for the efforts of the technologists.

Technical economy, which really made possible the increased wages of the union worker, now is unable to keep up its end of the race. The profit is being taken out of capital, and if labor is to demand an ever-increasing wage rate, technology and management cannot provide the wherewithal—and bankruptcy must follow. Then, if the industry is essential, either the state or the worker must take over industry and run it.

The more union labor freezes wages at an irreducible level, the slower the reabsorption of labor following an intensive invention, and the more difficult the engineering and management part of the problem.

It seems that engineers stand somewhere between capital and labor, but always with an opportunity to move up into the capital and executive bracket. If engineers unionize, will they still have the opportunity of advancing into this upper bracket? There are numerous arguments for and against the unionization of engineers. An attempt will be made in this article to discuss both sides of the question.

ENGINEER'S STATUS

Engineers attain professional status in a unique way. Upon completion of the prescribed formal education for their prospective fields, lawyers and physicians are inducted immediately into the profession by joining forces with others of the same profession in an established office or by opening an office of their own. This is not usually true in the case of the engineer. An engineer, upon the completion of his formal education, may obtain employment as general roustabout doing things which more often than not give no immediate evidence of a need of higher mathematics, advanced engineering knowledge, or ability to apply engineering technique. This means that the young engineer, coming out of school, must gain his practical experience and earn his professional status in the rough and tumble of the subprofessional group, only partly protected by his technical standing.

In this stage of his career he is, in all probability, an employee, and as such he can avail himself of the protection afforded by the legislation which greatly promotes collective bargaining; for example, the National Labor Relations Act of 1935.

Section 8 of the Wagner Act specifically states that it shall be an unfair labor practice for an employer:

1. "To interfere with, restrain, or coerce employees in the exercise of the rights guaranteed in Section 7" which reads "employees shall have the right to self-organization, to form, join or assist labor organizations, to bargain collectively through representatives of their own choosing, and to engage in concerted activities, for the purpose of collective bargaining or other mutual aid or protection."

2. "To dominate or interfere with the formation or administration of any labor organization or contribute financial or other support to it . . . ."

This was followed three years later by the Wage-Hour Law, which fixed a minimum rate of pay of 40 cents an hour and a maximum work week of 40 hours, and

imposed new restrictions on employers with penalties for their violation.

The law, however, does not compel professional employees to join a labor union, unless a majority of a group of such employees votes in favor of joining.

"In general, technical employees . . . are paid on a salary basis and have much different qualifications than the production employees; a substantial number of technical employees are college graduates. In accordance with our customary policy, we shall exclude technical employees from the appropriate unit."
(Sunbeam Electric Manufacturing Company, 42 NLRB 825, July 23, 1942.)

"We believe that the desire of these employees themselves is the chief factor to be considered in determining whether they shall constitute a separate unit or become part of a larger unit."
(Simmonds Aerocessories, Inc., 42 NLRB 179, July 8, 1942.)

"We hold, therefore, that the desires of the employees shall govern, and we shall direct that separate elections be held."
(American Smelting and Refining Company, 42 NLRB 736, July 22, 1942.)

These decisions make it clear that the National Labor Relations Board will not force technical employees against their will into a union of production employees, but they also show that if a majority of a group of technical employees wishes an organization for collective bargaining, the board will approve it.

The engineer has the choice of working his way up with what help his profession can give him (if necessary, in cases of unfair discrimination, he can avail himself of recent legislation and form with others a bargaining group unaffiliated with organized labor); or he can join with organized labor. If he chooses the latter course, he becomes a member of the labor group and relinquishes his rightful place as a part of management. If he joins with organized labor he contributes financially to the support of the labor pressure group, which certainly is not looking out for the interest of the profession or of management.

STRENGTH OF LABOR UNIONS

In 1929, one of the most prosperous peacetime years, the membership of organized labor totalled approximately 3.5 million workers. During the depression, labor union membership declined to less than 3 million. In 1933 the labor movement surged forward aided by improved business conditions. Today labor organizations, according to various estimates, have a membership of between 12 and 13 million, and wage contracts negotiated by them probably apply to an additional three or four million.

Because of the trend of the times and recent legislation, labor unions have grown strong as a matter of course and have obtained for their members remuneration out of proportion to that of other types of employees, such as those in the engineering profession. Because of the fact that so many engineers are employees needing group strength, they look sympathetically on this trend toward grouping, collective bargaining, and unions.

One of the most frequent arguments against the unionization of engineers is the claim that unions tend to increase the costs of production, while it is the business of the engineer to reduce the same. This claim may refer to various points. The first one is the question of wages, the primary objective of union activities. The wage question is not an engineering problem, it is a matter of bargaining and of supply and demand on the labor market. The second point is a better utilization of labor by means of motion studies, improved organization, better tools and machines, and the other well-known methods. These are engineering problems, but they, too, interfere with the spreading of employment, consequently, even the most gifted, experienced, and zealous engineer will not be able to overcome the reluctance of the workers against these methods, whether he be union member himself or not.

Whatever the truth of the matter, the question in the present connection is whether the engineer could secure a smoother flow of operation and co-operation from the employees under him, if he, too, were a union member.

At present, the unionized worker, even though he may have a personal esteem toward some individual engineer, looks with contempt and scorn at the non-unionized engineer in general whom he considers to be an employee like himself, even if of a different trade, only with not enough backbone and intelligence to join a union. Many believe that this unsound relationship between engineer and worker could be changed for a much better one if the former, too, would become a union member. There is a probability that some of the present labor troubles might have been avoided through the more reasonable, cool-blooded, and intelligent active co-operation of union-member engineers.

Viewing the situation from another angle, union membership tends to draw a line between employers, who are defined as persons with the right to hire and fire, and employees. In the case of engineers this would mean in many instances that the older more experienced men, from whom the younger men should learn, could not belong to the same organization as the younger engineer.

The typical union is concerned exclusively with the economic well-being of its members, and with the public welfare only insofar as the union members may be able to take advantage of that welfare. Is this a suitable and proper attitude for a profession?

"A profession is a calling dealing with spiritual, physical, or social laws, principles and aspirations, and requiring expert knowledge, inherent skill, and strong moral purpose in the application of the same to the conduct of life and the affairs of men."

ENGINEERING IDEALS

The highest ideals of the engineering profession were expressed forcefully by Doctor Vannevar Bush in his address before the meeting of the American Engineering Council in January 1939. He spoke of "the heights of

true professional attainment, where honor and individual recognition by fellows is the real reward, and where the watchword is that old, old theme, which has never lost its power, and which yet may save a sorry world, simple ministration to the people."

Engineers in a number of occupations and localities have been subjected to considerable pressure to unionize. This pressure usually is brought about by outside organizations, rather than from the engineers themselves. Most of the engineers who have urged unionization are those engineering graduates who never really have become engineers because of inability to keep up with the advancements of the profession; or who have been so unfortunate as to obtain employment with firms having the short-sighted policy of getting from their technical staffs all the service possible by paying a minimum wage rather than a just compensation for the work done.

Mr. Average Engineer has overwhelming power technically, but as a professional unit his voice has been inaudible. He is a member of the youngest of all the learned professions, in which most of the branches are not yet a lifetime old. In a day of economic confusion when great new forces are sweeping over us in industry, he cannot, if he would, remain a solo performer.

Thus engineers in industry are faced with a question which, for any particular group, may at any moment become acute and pressing. Should they set up a collective bargaining agency of their own to serve their own interests and forestall a possible attempted grab by a production union?

If collective bargaining is desirable for engineers, then the answer seems clear. An agency organized by the engineers themselves obviously would be equipped better for such purpose, in understanding and common interest, than a union of production employees.

ROLE OF THE ENGINEERING SOCIETIES

The question as to whether engineers shall or shall not become members of a union must be considered entirely as a personal matter for each individual, who as such has the free right to choose what seems the better way.

One answer is a more active interest by the already established and respected national engineering societies in the various conditions of employment of engineers; in the education of their members in the legal and economic elements of collective bargaining; in giving to young engineers and those in the subprofessional group the special consideration they need; and in providing advice and help where there are acute employment difficulties.

The basic purpose of the American Association of Engineers, the National Society of Professional Engineers, and such organizations as the Bar Association and American Medical Association is similar to that of unions—that of advancing the economic position of the membership through collective action. But they differ radically in methods and in the fact that they include in their membership both employers and employees.

Let us not be deceived, the labor idea is widespread and growing among many young engineering graduates. If older engineers somehow do not make our great mass of younger graduates professionally minded, within a few years we may be largely trade union in pattern.

Actually, very few professional engineers have joined labor unions. Nevertheless, the difference between the remuneration of the profession and that of labor is unfair and some employee engineers definitely are seeking aid. One thing is clear—some engineers need help and this help should come from the profession itself.

In the writer's opinion, engineers and labor unions have so little in common that unionization of engineers is at least an unnatural development.

REFERENCES

1. Letter to the Editor, **W. L. Abbott.** *Mechanical Engineering*, volume 62, February 1940, pages 158–9.

2. AIEE Report on Collective Bargaining. *Electrical Engineering*, volume 64, July 1945, pages 239–45.

3. Letter to the Editor, **Gosta Anbra.** *Mechanical Engineering*, volume 62, May 1940, pages 411–12.

4. Letter to the Editor, **Andrew A. Bato.** *Mechanical Engineering*, volume 63, June 1941, pages 475–6.

5. Engineering Societies and Unions, **V. T. Baughton.** *Civil Engineering*, volume 9, February 1939.

6. Engineers and the Union Movement, **V. T. Baughton.** *Civil Engineering*, volume 7, September 1937.

7. Unions of Their Own Choosing, **Robert R. R. Brooks.** Yale University Press, Cambridge, Mass., 1939.

8. Letter to the Editor, **Gilbert L. Campbell.** *Mining and Metallurgy*, volume 25, August 1944, page 384.

9. Letter to the Editor, **James D. Cunningham.** *Mechanical Engineering*, volume 62, January 1940, page 69.

10. Letter to the Editor, **Howard E. Degler.** *Mechanical Engineering*, volume 62. May 1940, pages 412–13.

11. Letter to the Editor, **William D. Ennis.** *Mechanical Engineering*, volume 62, February 1940, pages 157–8.

12. Organization of the Engineering Profession, **James F. Fairman.** *Electrical Engineering*, volume 64, June 1945, pages 220–3.

13. Collective Bargaining and the Engineer, **L. A. Hawkins.** *Illuminating Engineering*, April 1944.

14. The Engineer and Management, **Lee H. Hill.** *Electrical Engineering*, volume 65, July 1946, pages 322–5.

15. Letter to the Editor, **Erwin C. Hoeman.** *Mining and Metallurgy*, volume 25, August 1944, page 384.

16. Engineer and Labor, **E. A. Holbrook.** *Civil Engineering*, volume 10, October 1940.

17. Letter to the Editor, **Virgil M. Palmer.** *Mechanical Engineering*, volume 62, May 1940, pages 244–5.

18. Letter to the Editor, **Howard F. Peckworth.** *Mining and Metallurgy*, volume 24, January 1943, pages 20–1.

19. The Engineer and His Future, **C. A. Powel.** *Electrical Engineering*, volume 64, January 1945, pages 14–16.

20. Union Rights and Union Duties, **Joel Seidman.** Harcourt, Brace, and Company, New York, N. Y., 1943.

21. Union Policies and Industrial Management, **Sumner H. Slichter.** The Brookings Institution, 1941.

22. Should Engineers Join a Union?, **R. W. Sorensen.** *Electrical Engineering*, volume 64, June 1940, pages 227–8.

23. Letter to the Editor, **Glenn J. Truax.** *Mining and Metallurgy*, volume 25, August 1944, page 383.

24. Unionism and the Engineering Profession, **C. J. Ullrich.** *Engineering*, volume 119, November 1937.

25. Letter to the Editor, **Charles E. Waddell.** *Mechanical Engineering*, volume 62, April 1940, page 328.

26. Letter to the Editor, **Clifford W. Welsh.** *Mechanical Engineering*, volume 62, January 1940, pages 68–9.

The Automatic Sequence Controlled Calculator—II

HOWARD H. AIKEN GRACE M. HOPPER

The second in a series of three articles, this article continues a discussion of the functions of the automatic sequence controlled calculator developed at Harvard University in cooperation with the International Business Machines Corporation. The calculator will carry out any selected sequence of the five fundamental operations of arithmetic (addition, subtraction, multiplication, division, and reference to tables of previously computed results) under completely automatic control. The functions considered herein are those of the multiplication and division registers and of the functional units.

THE REGISTERS GIVEN over to multiplication, division, and the functional units are shown in Figure 1. The counter wheels and allied controls involved in these two operations are interconnected electrically, in such a way that both multiplication and division cannot be carried on at the same time. The basic mode of operation is shown in the schematic diagram, Figure 2. In the case of multiplication, the multiplicand and the multiplier are read into the unit through in-relays connected to the bus as in the case of the storage counters. The out-relay, however, through which the product is read out of the multiply unit, connects to the bus through a plugboard provided to fix the decimal point relationship between the product counter and the bus.

The location of the decimal point is of no importance as far as the operation of the storage counters is concerned. When the operating decimal point is assumed to lie between columns n and $n+1$ in the switches and storage counters, the corresponding decimal point in the product counter will lie between columns $2n$ and $2n+1$. It is clear that the product counter must contain 46 columns and the algebraic sign. As only 23 of these columns and the algebraic sign normally may be read out into the bus, it is the purpose of the plugging to make a suitable selection of the columns to be read out based upon the location of the operating decimal point. The plugging must be adjusted manually before the machine is placed in operation.

Because the coding for multiplication must select the multiplicand and multiplier and deliver the product, it consists of three lines: multiply x in counter 56, code 654, by y in counter 18, code 52, and deliver the product xy to counter 13, code 431, (654, 761, blank), (52, blank, blank), (blank, 431, 7). Code 7 does not appear in the C column of the lines of coding selecting the multiplicand and multiplier and delivering them to the multiply unit. These are omitted because code B 761, the multiply code, is an automatic continue operation code and so replaces the 7's. No longer does each line of coding correspond to a single operation of the machine. The first line of coding delivers the multiplicand to the multiply unit, and turns over control of the calculator to a subsidiary sequence control within the multiply unit itself. The unit builds up and stores a multiplication table consisting of the nine integer multiples of the multiplicand. The multiply unit then signals the sequence control and calls for the multiplier. The process of multiplication is completed, within the unit, by withdrawing such multiples of the multiplicand as may be indicated by the multiplier and adding them together while shifting them to the proper columnar positions. Upon completion of this summation, control of the machine is turned back to the main sequence mechanism and the product delivered as indicated by the third line of multiply coding.

In the event that one or both of the factors involved in a multiplication are negative numbers, this fact is sensed and stored by the multiply unit. The factors then are treated as positive absolute magnitudes for use

---

Howard H. Aiken, commander, United States Naval Reserve, and officer-in-charge of the computation project of the Bureau of Ordnance, is on leave of absence as professor of applied mathematics, graduate school of engineering, Harvard University, Cambridge, Mass. **Grace M. Hopper**, lieutenant, United States Naval Reserve, is associate professor of mathematics, Vassar College, Poughkeepsie, N. Y., on leave of absence for naval service.

Design and construction of the automatic sequence controlled calculator was begun in 1939 at Endicott, N. Y., and continued until August 1944, when the machine was presented formally to Harvard University by T. J. Watson, president, International Business Machines Corporation. Commander Aiken wishes to express his appreciation to Mr. Watson for the support of International Business Machines Corporation during the years of development of the calculator and further to B. M. Durfee, F. E. Hamilton, and C. D. Lake, who, together with Commander Aiken, were coinventers of the machine. The relays, counters, cam contacts, typewriters, card feeds, and card punch employed in the calculator are all standard parts of tabulating machinery as constructed by International Business Machines Corporation.

The opinions or assertions contained in this article are the private ones of the writers and are not to be construed as official or as reflecting the views of the Navy Department or the naval service at large. Material for the article has been adapted largely from "The Manual of Operation of the Automatic Sequence Controlled Calculator," *Annals* of the Computation Laboratory of Harvard University, volume I, Harvard University Press, Cambridge, Mass., 1946 Permission to use this material has been granted.

in the multiplication. Finally, the proper algebraic sign is appended to the product and it is read out directly or inverted as required.

The bus is used during the multiplying operation only three times. If properly timed, other operations involving the bus but not involving either multiplication or division, inasmuch as these operations are interconnected electrically, may be carried on during multiplication. Such operations are known as "interposed operations."

SPECIAL OPERATIONS

When the operating decimal point of the calculator is assumed to lie between columns 23 and 24, the corresponding decimal point in the product counter will fall between column 46 and the algebraic sign. For this case, the multiply unit is equipped with a special out-relay permitting the read-out of columns 1 through 23 of the product counter to the bus. The normal multiplying operation, with suitable plugging, delivers columns 24 through 46 of the product counter to columns 1 through 23 of the bus as usual. The use of the special low order product out-relay in effect provides the machine with 46 column products as obtained from 23 column factors.

One of the two pairs of ganged counters may be used in combination with this special product read-out to build up the product of two quantities, either or both of which may consist of 46 or fewer digits. The error in such a multiplication will be less than or equal to 2.7×10^{-46}. Thus, if the quantity stored across counters A and B is multiplied by the quantity stored across counters C and D, three multiplications, $A\times C$, $A\times D$, $B\times C$, will be performed and the products summed in the ganged counters. The product $B\times D$ is neglected as it is below the capacity of the machine.

Although the organization of the multiply unit is far more complex than that of the storage counters, nevertheless it is possible to alter the multiplying circuits to permit special operations. For example, it sometimes is required to print a function which has a very wide range of values. In this case, it is convenient to print a fixed number of significant figures together with an associated power of ten. The "normalizing register," in conjunction with the multiply unit, accomplishes this purpose by shifting a quantity so that its first significant digit appears in bus column 23, and recording the amount of the shift. The amount of shift, combined in a storage counter with a constant dependent upon the position of the operating decimal point, supplies the exponent required.

DIVISION

Division, like multiplication, requires three lines of coding. These read the divisor and dividend into the divide unit and deliver the quotient to its specified destination using the connections shown diagrammatically in Figure 2: divide x in counter 3, code 21 by y in counter 4, code 3, and deliver the quotient to counter 5, code 31, (3, 76, blank), (21, blank, blank), (blank, 31, 7).

After the divisor and dividend are read into the unit, they are shifted and stored so that their first significant digits appear in the highest column of the registers in which they are stored. The number of columns that the dividend was shifted and the complement on nine of the number of columns the divisor was shifted are added together in the "Q-shift" counter. A constant dependent upon the position of the operating decimal point is supplied to the Q-shift counter by a manually preset switch known as the divide switch. Since the Q-shift counter is not equipped with an end around carry circuit, the addition of a one in the units column completes the determination of the number of columns the quotient must be shifted when it is read out into the bus in proper decimal position. A one added into the units column of a counter to compensate for a missing end around carry commonly is known as an "elusive one."

As soon as the divisor is delivered and control of the calculator turned over to the divide unit, a table of the nine integer multiples of the divisor is built up and stored within the unit. When called upon the main sequence mechanism delivers the dividend. Under the subsidiary sequence control, the multiples of the divisor are compared with the dividend and the largest multiple less than the dividend selected. This multiple then is subtracted from the dividend while the digit defining it is entered in the quotient counter. The process of division is continued in this manner, successively comparing, subtracting, and shifting to the right. As the successive subtractions involve different columnar positions of the dividend counter, an end around carry cannot be provided. The subtractions are accomplished by means of complements on nine together with elusive ones introduced into the units column of each succeeding subtrahend.

If, upon comparison, the calculator finds that all multiples of the divisor are greater than the dividend or the remainder under consideration, a zero or "no-go" is entered in the quotient counter and a new comparison made one column to the right.

Division may be terminated after any desired number of comparisons by place limitation plugging and coding. The number of significant digits in the quotient will be either equal to the number of comparisons made or to this number less one (if the first comparison yields a no-go). The place limitation coding puts the accuracy of division under control of the main sequence mechanism so that the accuracy may be varied as desired within any given problem.

The quotient is read out into the bus through that part of the out-relay selected by the quantity standing in the Q-shift counter. If a negative number is shifted to

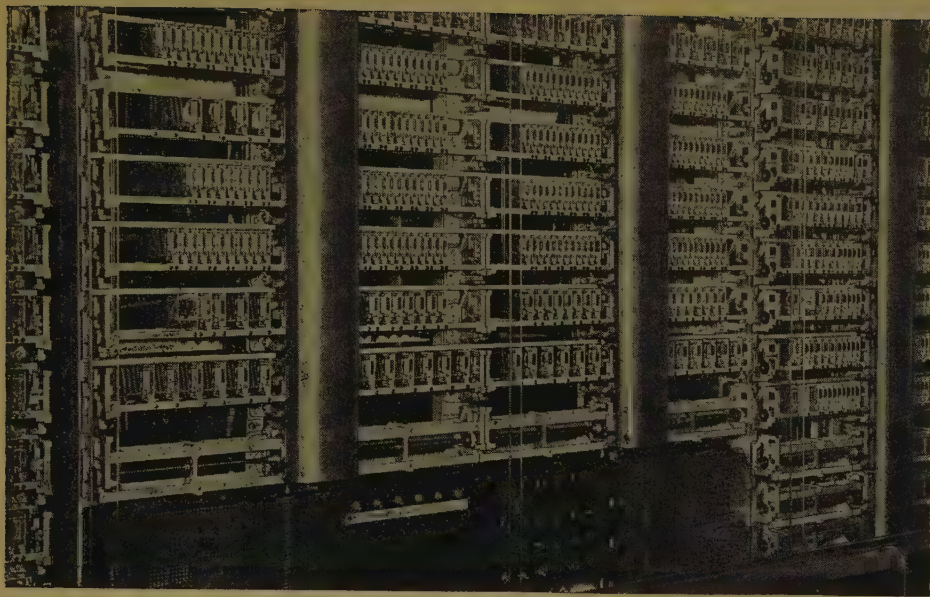


Figure 1. Multiply-divide and functional counters

the right, the out-relay also supplies the nines at the left required to complete the complement on nine of the quotient. The algebraic sign is determined by the methods employed in the case of multiplication.

Further, as in multiplication, the bus is used only three times during division, and is otherwise free for any interposed operations not involving either multiplication or division. It now should be clear that many of the electromechanical operations necessary to multiplication and division are identical, but controlled by two separate subsidiary sequence control systems.

ITERATIVE PROCESS FOR RECIPROCALS

Though it is not immediately evident, division consumes almost four times as many cycles of machine time as does multiplication and uses a great deal more apparatus. Obviously, this process is to be avoided whenever possible. Fortunately, an iterative process based on the Newton–Raphson[1] rule,

$$x_{n+1}=x_n-f(x_n)/f'(x_n),\ n=0,\ 1,\ 2,\ \ldots \tag{1}$$

is available for finding reciprocals. Let

$$f(x)=N-1/x \tag{2}$$

Then,

$$x_{n+1}=x_n(2-Nx_n) \tag{3}$$

defines a sequence, x_n, which converges toward the reciprocal of N. Each succeeding application of the iterative process roughly squares the error of the preceding approximation.

Suppose that in a given computation the values of the independent variable increase in an arithmetic sequence. Under these circumstances, the reciprocal of the nth value of the variable in general will furnish a good first approximation to the reciprocal of the $(n+1)$st value. Thus the process of division may be avoided with a considerable gain in the speed of computation. The application of equation 3 to the design of calculating machinery first was suggested by Aiken in 1938.[2] Equation 3 also provides the calculator with a means of dividing to an accuracy of 46 significant digits. The Newton–Raphson rule, by proper choice of $f(x)$, may be made to yield an iterative process for obtaining any fractional power of a given number so long as a suitable first approximation is available. This fact greatly extends the usefulness and speed of operation of the calculator without the inclusion of a single special electrical circuit.

On the other hand, the computation of the elementary transcendental functions may not be disposed of so easily. These require special registers as well as subsidiary sequence controls.

COMPUTATION OF LOGARITHMS

The method of computation of logarithms (Figure 3) within the calculator depends upon two equations,

$$\log\,(a\cdot b\cdot c\ldots)=\log a+\log b+\log c+\ldots \tag{4}$$

and

$$\log_e\,(1+h)=h-h^2/2+h^3/3-h^4/4+\ldots+(-1)^{n+1}h^n/n+\ldots \tag{5}$$

for $h^2<1$. The logarithm unit includes two counters known as the logarithm counter and the logarithm in-out counter, together with a subsidiary sequence control which governs these counters in conjunction with the multiply-divide unit. If it is desired to compute $\log_{10} x$, the coding in the main sequence control tape will read as follows: x lies in counter 39, code 6321, deliver $\log_{10} x$ to counter 8, code 4, (6321, 762, blank), (831, 4, 7), (blank, blank, 763). At the same time that x is read into the logarithm in-out counter, the code B 762 signals the logarithm subsidiary sequence control to take over the direction of the calculator. From the logarithm in-out counter, x is read to the logarithm counter so shifted that the first significant digit of x appears in the 23d column of the logarithm counter. The amount of the shift is recorded and its complement on ten entered in columns 22, 23, and 24 of the logarithm in-out counter, in which the decimal point now is considered to lie between columns 21 and 22. The computation of the

characteristic of x then is completed by adding $22\text{-}n$ into the logarithm in-out counter, the operating decimal point being between columns n and $n+1$. This quantity is supplied by a manually preset constant register known as the logarithm switch. For example, if the operating decimal point lies between columns 15 and 16 and $x=783.54210\ 50928\ 67954$, x is shifted five columns to the left on reading from the logarithm in-out counter to the logarithm counter. In this case, $22-n=7$. Hence, the characteristic of x is computed as $995+007=002$.

Now $\bar{x}=7.83542\ 10509\ 28679\ 54$ stands in the logarithm counter with the decimal point following its first significant digit, and it is only necessary to compute the mantissa of $\log_{10} \bar{x}$. This computation perhaps is explained best by a numerical example. Four successive divisions are performed:

$$\bar{x}/7=1.11934\ 58644\ 18382\ 79142\ 85;$$
$$\bar{x}/(7)(1.1)=1.01758\ 71494\ 71257\ 08311\ 68;$$
$$\bar{x}/(7)(1.1)(1.01)=1.00751\ 20291\ 79462\ 45853\ 14;$$
$$\bar{x}/(7)(1.1)(1.01)(1.007)=1.00050\ 84698\ 90230\ 84263\ 30.$$

Equation 4 becomes

$$\log 7.83542\ 10509\ 28679\ 54=\log 7+\log 1.1+\log 1.01+\log 1.007+\log 1.00050\ 84698\ 90230\ 84263\ 30 \quad (6)$$

The logarithm table relays store $\log_{10} \mathcal{N}$ accurate to 21 decimal places, for $\mathcal{N}$ equal to: 1.0, . . ., 9.0, 1.1, . . ., 1.9, 1.01, . . ., 1.09, 1.001, . . ., 1.009. The internal logarithm sequence controls select the four logarithms called for by the first four terms on the right side of equation 6 and deliver them to the logarithm in-out counter for summation.

The last term of the logarithmic sum in equation 6 is of the form $\log\ (1+a10^{-4})$ where $a<10$. Writing $(1+a10^{-4})=1+h$, then $h<10^{-3}$. In using equation 5, six terms of the series are employed. Therefore, the remainder of the series will be

$$R<h^7(1+7h/8+7h^2/9+7h^3/10+\ldots)/7,$$
$$R<h^7(1+h+h^2+h^3+\ldots)/7,$$
$$R<h^7/7(1-h),$$
$$R<10^{-21}/7(0.999).$$

Clearly, the choice of four divisions and six terms of the series puts the error below the lower limit of the capacity of the machine. The series given in equation 5 is used by the machine in the form

$$\log_{10}(1+h)=(((((hc_6+c_5)h+c_4)h+c_3)h+c_2)h+c_1)h$$

where

$$c_1=M,\ c_2=-M/2,\ c_3=M/3,\ c_4=-M/4,\ c_5=M/5,\ c_6=-M/6:\quad M=\log_{10} e$$

The values of the c's also are stored in table relays and supplied to the multiply unit as directed by the logarithm sequence controls. One feature of these controls, not previously mentioned in this discussion, permits the multiplicand, h, and its multiples to remain stored in the multiply-divide unit throughout the evaluation of the series, thus saving considerable machine time.

After summing all terms of equation 6 in the logarithm in-out counter $\log_{10} x$ is read out into the bus through plugging inasmuch as it stands with its decimal point between columns 21 and 22 and must be shifted to conform with the operating decimal position.

The exponential function, or antilogarithm, is derived by a reversal of the process used to compute logarithms. The method of computation is dependent upon the equations

$$10^x=10^{10a+b}\cdot 10^{c/10}\cdot 10^{d/100}\cdot 10^{e/1{,}000}\cdot 10^f \quad (7)$$

$$10^f=e^h=1+h+h^2/2!+h^3/3!+\ldots \quad (8)$$

where $h=f\log_e 10$.

The exponential unit includes the exponential in-out counter and a subsidiary sequence control governing this counter in connection with the multiply-divide unit. In order to compute 10^x, the main sequence control tape

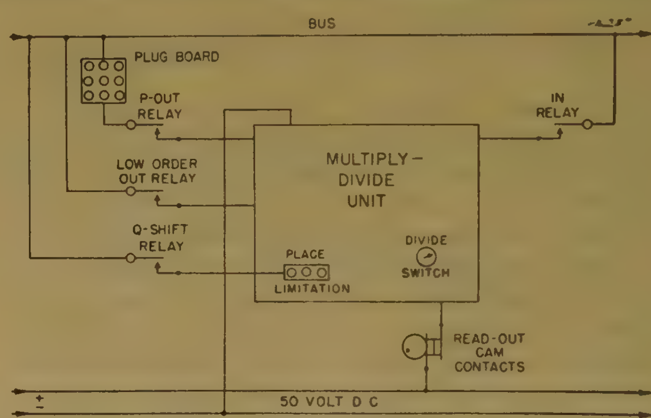


Figure 2. Multiply-divide unit

must read as follows: x lies in counter 27, code 5421; deliver 10^x to counter 20, code 53, (5421, 7621, blank), (blank, 741, blank), (832, 53, blank), (blank, blank, 731).

CALCULATION OF SIN x

The third electromechanical table contained within the calculator is that of the function, $\sin x$. The method of computing $\sin x$ is based upon the equations

$$\sin(-x)=-\sin x \quad (9)$$

$$\sin(x+2n\pi)=\sin x \quad (10)$$

$$\sin x=\cos(\pi/2-x) \quad (11)$$

$$\sin x=x-x^3/3!+x^5/5!-x^7/7!+\ldots+(-1)^n x^{2n+1}/(2n+1)!+\ldots \quad n=1,2,3,\ldots,10 \quad (12)$$

$$\cos x=1-x^2/2!+x^4/4!-x^6/6!+\ldots+(-1)^n x^{2n}/(2n)!+\ldots \quad n=1,2,3,\ldots,10 \quad (13)$$

Inasmuch as the series of equations 12 and 13 are alternating series the remainder, R, will be less than the first term omitted. Assuming

$$x\leq\pi/4,\quad |R|<(\pi/4)^{22}/22!$$

Taking the logarithm of both sides of the inequality,

$$\log_{10}|R| < 22(\log_{10}\pi - \log_{10} 4) - \log_{10}(22!)$$
$$< 22(0.498 - 0.602) - 21.050$$
$$< -23$$

Thus $|R| < 10^{-23}$ and the error in using these series for computation falls below the capacity of the calculator.

The sine unit (Figure 4) is composed of the sine in-out counter and subsidiary sequence circuits having control

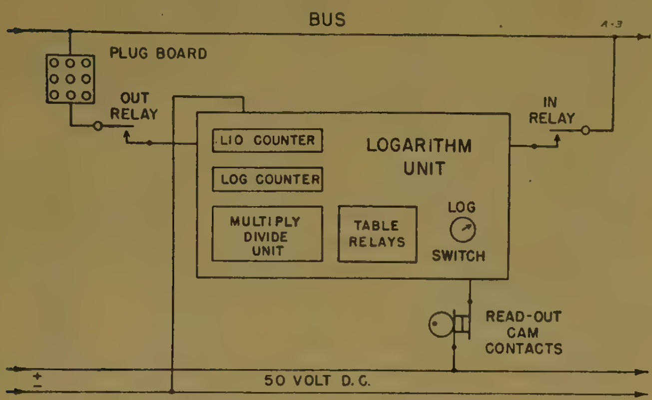


Figure 3. Logarithm unit

of this counter, the multiply unit and certain table relays providing the coefficients of the series together with other necessary constants such as $\pi/4$, $\pi/2$, $\pm\pi$, and 2π. The main sequence control tape dictates the computation of sin x by the coding: x lies in counter 14, code 432; deliver sin x to counter 40, code 64, (432, 7631, blank), (84, 64, 7), (blank, blank, 7321).

In order to compute sin x, it first must be determined in which quadrant x falls. The first operation in the sine sequence multiplies x by $1/2\pi$ (supplied by a table relay through plugging) at the operating decimal position. Then the product $|x|/2\pi$ is read into columns 1 through 23 of the sine in-out counter with decimal point at the operating position. At the same time, the algebraic sign of x is read into the 24th column of the sine in-out counter. Let $|\bar{x}|/2\pi$ indicate $|x|/2\pi$ with its integral part omitted. This integral part represents multiples of 2π which may be dropped by virtue of equation 10. Through plugging, $|\bar{x}|/2\pi$ next is read from the sine in-out counter to the multiplicand counter so shifted that its decimal point lies between columns 22 and 23. The algebraic sign of x remains stored in the sine in-out counter. The integer four, supplied by a table relay, is read to the multiplier counter. The resulting product is read into the sine in-out counter with its decimal point between columns 22 and 23. Four cases now may be distinguished:

(α) $0 \leq 2|\bar{x}|/\pi < 1$, x in quadrant I, sin $|x| \geq 0$
(β) $1 \leq 2|\bar{x}|/\pi < 2$, x in quadrant II, sin $|x| > 0$
(γ) $2 \leq 2|\bar{x}|/\pi < 3$, x in quadrant III, sin $|x| \leq 0$
(δ) $3 \leq 2|\bar{x}|/\pi < 4$, x in quadrant IV, sin $|x| < 0$

Which of these four cases appertain in the case of a specific value of x may be determined by sensing the integer in the 23d column of the sine in-out counter. The value of this integer together with the algebraic sign of x previously stored in the 24th column of the sine in-out counter completes the determination of the sign of sin x.

The procedure by which this is accomplished, and by which x is reduced to a first quadrant angle, now will be discussed. The quantity $2|\bar{x}|/\pi$ is multiplied by $\pi/2$ and when this operation is completed, the product, $|\bar{x}|$, is read into the sine in-out counter. During this multiplication, the sensing circuits on column 23 of the sine in-out counter order the following operations:

1. Reset all columns but the 24th of the sine in-out counter.
2. Case (α): $0 < |\bar{x}| < \pi/2$
$|\bar{x}|$ is read into the sine in-out counter directly;
Case (β): $\pi/2 \leq |\bar{x}| < \pi$
$|\bar{x}|$ is inverted when read into the sine in-out counter,
π is added into the sine in-out counter;
Case (γ): $\pi \leq |\bar{x}| < 3\pi/2$
$|\bar{x}|$ is read into the sine in-out counter directly,
$-\pi$ is added into the sine in-out counter,
a nine is added into the 24th column of the sine in-out counter;
Case (δ): $3\pi/2 \leq |\bar{x}| \leq 2\pi$
$|\bar{x}|$ is inverted when read into the sine in-out counter,
2π is added into the sine in-out counter,
a nine is added into the 24th column of the sine in-out counter.

Inasmuch as the sine in-out counter has no end around carry, and inasmuch as any digit other than a nine in the 24th column of this counter is the equivalent of a zero, the final algebraic sign of sin x now stands in the 24th column of the sine in-out counter. The reduced first quadrant angle, X, corresponding to the given value of x stands in the remaining columns.

Two cases remain to be distinguished:

(a). $0 \leq X < \pi/4$;

(b). $\pi/4 \leq X \leq \pi/2$.

After a sensing circuit has compared the value of X with $\pi/4$, in case (a), the computation proceeds by evaluating the series of equation 12. In case (b), $\pi/2 - X$ is formed and the series of equation 13 is evaluated. In either case, the result of the summation of the series is delivered to the sine in-out counter, columns 1 through 23, with the result that this counter then contains $|\sin x|$ and the appropriate algebraic sign.

The read-out of sin x to the bus for delivery to storage is through plugging, in order to shift the function to conform to the operating decimal position. The read-out is direct or inverted according as zero or eight on the one hand, or a nine on the other hand, stands in the 24th column of the sine in-out counter.

The logarithm in-out counter and the sine in-out counter commonly are used as "shift counters." These counters are equipped with pluggable and direct read-ins and read-outs. They may be used to multiply or divide by powers of ten. In addition, the pluggable read-

outs may be adjusted manually so as to permit selective read-out of the shift counters by means of which any m columns may be delivered to the bus while the remaining $24-m$ are suppressed. This selective read-out does not erase any part of the number standing in the shift counter. The read-ins and read-outs of these two counters have been placed under control of the main sequence mechanism by codes which are independent of the codes of the functional units of which the shift counters are themselves a part.

THE MECHANICAL INTERPOLATORS

With the aid of the electromechanical tables of $\log_{10} x$, 10^x and $\sin x$, all of the elementary transcendental functions, including the hyperbolic functions, may be obtained through the use of the operations of the calculator already described. In order to provide for inverse trigonometric functions, higher transcendental functions, and empirical functions defined by tabular data, the calculator is equipped with three mechanical interpolators.

The three interpolator mechanisms and their accompanying switches are on the left of the main sequence mechanism. The three units share in common the interpolation counter and the interpolation check counter. A function is introduced into an interpolation mechanism in the form of a perforated paper tape. This tape is similar to the main sequence control tape, but in place of commands to the calculator, contains coded successive equidistant values of the argument, each accompanied by the necessary interpolational coefficients. Any order of interpolation up to and including the 11th may be employed.

A function $f(x)$ is to be determined by means of Taylor's series. The independent variable, x, is considered as consisting of two parts, $x=a+h$, where a is an integral multiple of a power of ten. As four columns are provided for containing the value of a, it is clear that a functional tape may contain 10^4 arguments.

An interpolation is performed by evaluating the series

$$\begin{aligned} f(x) &= f(a+h) \\ &= f(a)+f'(a)h+f''(a)h^2/2!+\ldots \\ &= c_0+c_1h+c_2h^2+c_3h^3+\ldots \end{aligned} \qquad (14)$$

in the form

$$f(x)=f(a+h)=((((\ldots+c_4)h+c_3)h+c_2)h+c_1)h+c_0 \qquad (15)$$

TWO PARTS TO INTERPOLATION PROCESS

The interpolation process may be divided into two distinct parts. The first consists of positioning the functional tape, and the second of the computation necessary to the interpolation itself. For tape positioning, the argument, a, and the highest order column of h are delivered to the interpolation counter. The interpolator mechanism first reads the tape to discover the position at which the tape is standing. By subtraction in the interpolation counter, the number of arguments the

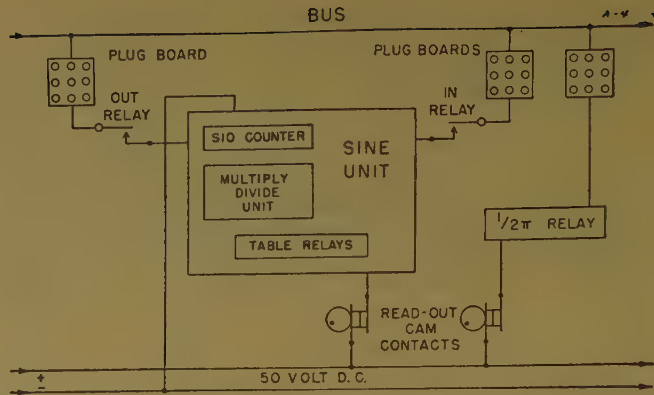


Figure 4. Sine unit

mechanism must pass over in order to arrive at the required argument is determined. To accomplish tape positioning in the shortest possible time, functional tapes are made endless. Suitable sensing circuits aided by manually preset switches direct the mechanism to move the tape in the direction of shorter travel. The highest order column of h is combined with a half-correction in the interpolation counter to insure positioning to the nearest argument. As the tape steps, the number of arguments to be covered (stored in the interpolation counter) is reduced one for each argument passed and finally is reduced to zero.

At the beginning of the positioning operation the required argument, a, is read into the interpolation check counter. At the end of the positioning operation it is transferred to the interpolation counter and used to check the position of the tape. If the tape is not in proper position because an impossible argument has been sent to the interpolation unit or because of faulty mechanical operation, the positioning mechanism will try a second time to find the required argument. The calculator is stopped and a red light turned on in the event that the positioning mechanism fails on this second try.

However, if the tape is found to be in the required position, the interpolation sequence control takes over command of the calculator. The quantity x again is read out of storage into the bus and the h part delivered by plugging to the multiply unit. Suitable corrections of h, such as nines to the left if h is negative, also are made by plugging.

The interpolation sequence control then evaluates the series of equation 15, while the multiplicand, h, is held constant as usual to conserve machine time. The coefficients, c_n, c_{n-1}, . . ., c_1, c_0, are read out of the functional tape and added into the multiplier counter under control of the interpolation sequence circuits.

Part III, the concluding portion of this article will appear in a subsequent issue.

REFERENCES

1. E. T. Whittaker, G. Robinson. The Calculus of Observations, third edition (London, England), 1942, pages 84–91.
2. H. H. Aiken. Harvard Lecture Notes on Applied Mathematics, 1938, page 10.

Short Survey of Japanese Radar—II

ROGER I. WILKINSON
ASSOCIATE AIEE

Part II of a Japanese radar survey continues a report based on a study made by the United States Army which was particularly fruitful because of the obvious willingness of the Japanese to volunteer technical information, in spite of the difficulties of interrogating in a foreign tongue or through an interpreter unfamiliar with technical terminology. Because radar research was carried on separately by the army and navy in Japan, this article complements Part I's discussion of army radar with a summary of naval developments in the same field, as well as discussing general factors incidental to the manufacture and operation of radar equipment.

RESEARCH AND DEVELOPMENT of navy radar and allied equipment were vested in the electronics section of the Second Naval Technical Institute located near the Yokosuka Naval Base. The section was under the direction of Vice Admiral Nawa, an electrical engineering graduate of Tokyo Imperial University. A rather capable staff of physicists and engineers was employed, some civilians, some commissioned officers. Doctor Takeyanagi, a name known in television circles, was assistant chief of radar research. The staff received no outside assistance except for one Mr. Brinker, an unwelcome arrival from Germany who came to work in the laboratory at the direction of higher navy officials. The Japanese engineers felt that they were quite able to meet any radar problems that the navy might bring up. Thus the navy handled the majority of its own electronic research work, while in the army the tendency was to assign various projects to outside research agencies, such as the universities and the manufacturers.

The naval institute's electronics division employed 350 technicians including 80 engineers and scientists. The annual budget amounted to 100,000,000 yen* which included the costs of making prototypes for all land, air, and ship-borne communications and radar. The actual installation on ships, however, was not handled by the institute. The activities of the radar and communication department of the institute since 1940 include studies on tubes, materials, and test equipment; circuit development; and the testing of many components and complete radar and radio sets.

One development of some interest was apparatus *A*, by which the Japanese proposed to cause their own shells to explode at predetermined positions or heights by passing them through a strong beam of centimeter radiation. Although the Japanese did succeed in 1944 in generating ten kilowatts of continuous power at a 20-centimeter wave length, the idea failed because of the "lack of an adequate receiving apparatus."

The work conducted on magnetron research, under the direction of Captain Ito, a former student of Professor Okabe at Osaka University, is of particular interest. It may have come as something of a surprise to American intelligence officers and radar engineers that the navy was producing 10-centimeter magnetrons suitable for use in their ship-borne search sets as early as the fall of 1941. Thus, their microwave studies at that time were but a few months behind similar studies being conducted in the United States. In the succeeding years, however, American development outdistanced Japanese, inasmuch as the best the latter could do was to produce a tube giving about five or six kilowatts peak output at ten centimeters. Most recent magnetron researches by the navy had resulted, on an experimental basis, in tubes yielding 1.5 kw of pulsed power at 2.7 centimeters and "just observable" powers at 0.7 centimeter. Commercial research organizations displayed magnetrons for which they claimed outputs as high as 26 kw at 2.8 centimeters. A summary of navy radar developments is given in Table I.

NAVY WARNING RADAR SETS

Research and development work on type *B* (pulsed radar was begun by the Japanese navy early in 1941). The well-known type 11 (mark 1 model 1) 40-kw 100-megacycle set found at Attu and Guadalcanal was developed in the period between April 1941 and March 1942. The Japanese report that the first number 11 set was installed at Rabaul. Altogether, about 80

Based upon an official report, "A Short Survey of Japanese Radar," prepared by the Second and Third Operations Analysis Sections for Headquarters, United States Army Air Forces, from studies made by the Analysis Sections and the Air Technical Intelligence Group, Far East Air Forces, United States Army.

Acknowledgment is made of the services of Robert P. Featherstone, formerly captain, Army of the United States, who assisted in the collection of information contained in this survey.

Roger I. Wilkinson was operations analyst for the 13th and Far East Air Forces from October 1943 to December 1945. His assignment after the fall of Japan was to study all phases of Japanese electronics and radar from research to operations. He now is back with Bell Telephone Laboratories, New York, N. Y.

* In purchasing power roughly equivalent to 100 million dollars in the United States.

Figure 1. Ship-borne 10-centimeter radar set number 22 for surface search

Under bench, left to right: Antenna control handles, rectifier
On bench, left to right: Receiver, indicator for warning, receiver control panel, transmitter, transmitter control panel
On wall: Antenna azimuth indicator

of these large early-warning sets were manufactured.

Soon after, work was begun on a smaller set which would not require the building of the large number 11 sets on distant islands, and several portable models were developed. Set number 12, of 5-kw power and working at 20 megacycles, appeared at the end of 1942; it later was adapted for ship-borne use also although throughout its life it was troubled with frequency instability. Set number 13, 10 kw at 150 megacycles, followed as a very lightweight unit in 1943, while simplified number 13, that is number 13K, was making its appearance just as the war ended. In the fall of 1944 when the B-29 raids began in earnest, the Japanese decided they needed a set which would give them longer range warning than any of the sets then in use. A long wave 6-meter set was "crash-engineered" and then built in three weeks. Three of these sets eventually were installed, two on the southern shores of Honshu, and the third at the very southeastern tip of Kyushu. Ranges obtained on high flying B-29's were consistently of the order of 300 kilometers.

The first of the long line of number 22-type ship-borne 10-centimeter search sets was completed in June 1942. The transmitter is powered by an M-312 magnetron, the anode of which is water-cooled by a motor-driven pump. The tube delivers a peak power of approximately six kilowatts with 11,000 volts applied to the anode. Power is transmitted through circular cross section wave guide to a horn antenna. A separate horn is used for receiving to obviate the loss and complication in a transmit–receive (TR) tube to accomplish electronic switching. A blocking oscillator provides the 10-microsecond keying pulse at a rate of 2,500 per second under the control of a tuning fork. The receiver is a superheterodyne with crystal detector and magnetron M-60-S as local oscillator. The intermediate frequency is 14.5 megacycles, the total receiver gain amounting to 120 decibels. The display is on two type-*A* cathode ray tubes. One tube called the "indicator for warning" shows all target echoes up to 60 kilometers. Range pips generated by shock exciting a crystal appear every five kilometers. A 3-microsecond range pulse is moved along as the range crank is turned. The second, or "range operator's oscilloscope" gives an expanded view

Table I. Radar Equipment Developed by the Japanese Navy

Power and range figures given indicate maximum for each classification

Classification	Number of Types Studies	Objectives	Frequency (megacycles) or Wave Length (centimeters)	Power Output	Range
Land-based radar	22	For use in antiaircraft warning, searchlight and antiaircraft fire control, altitude measurement, and identification of aircraft	2 at 60, 6 at 100, 5 at 150, 7 at 200, 2 at 500 megacycles	to 100 kw	to 450 kilometers
Ship-borne radar	20	For use in antiaircraft and anti-surface warning and fire control	4 at 150, 6 at 200, 1 at 500 megacycles; 1 at 28, 8 at 10 centimeters	to 30 kw	to 100 kilometers
Air-borne radar	11	For use in patroling and searching, aircraft identification, altitude measurement, and path finding	6 at 150, 1 at 250, 1 at 340, 2 at 500 megacycles; 1 at 10 centimeters	to 20 kw	to 150 kilometers
Land-based, ship-borne, and air-borne radar counter measures	9	Search receivers to determine data on enemy radar	3 centimeters–4 meters	Receivers only	

of about 1,000 meters of the range as selected by the range crank. A magnifying glass in front of the oscilloscope gives it a size equivalent to a 5-inch tube. The true range is read on a dial when the target pip's leading edge is set just even with a vertical line inscribed up the face of the tube. The range obtainable on a battleship was of the order of 25 kilometers. This set was agreed by army and navy alike to be one of the most satisfactory radars used by the Japanese forces. Members of the navy laboratory assembled a 22 set at their Tsukishima test area in Tokyo's eastern suburbs for viewing by United States Army air personnel. Excellent definition was obtained on targets in Tokyo Harbor. Figure 1 shows a bench set up with the transmitter, receiver, and indicator for warning. Figure 2 shows the range unit.

Figure 2. Range unit for type 22 radar

A somewhat simplified version of number 22 called modification-3 was installed in the conning towers of submarines. It used two horns mounted side by side. Presentation was on a single *A*-type 75-millimeter oscilloscope. Range was about ten kilometers on a battleship.

For ship-borne air warning a modification of the number 12 land-based set (renamed number 21) was used, and the number 13 land-based set also was adapted for the same purpose.

The first development work on air-borne radars was done by the navy in November 1941. It resulted in a patrol and search set (number H-6) working at 150 megacycles. During the years that followed, some 2,000 of these sets, which gave excellent satisfaction, were manufactured. The H-6 eventually gave way to the lighter and more compact FK-3 in the latter months of the war.

The navy well appreciated the desirability of obtaining better definition than could be realized from the 150-megacycle sets used for sea patrolling if they were to be able to do radar bombing. Some work was done in an attempt to adapt the 10-centimeter number 22 ship-borne set for this purpose, but the project was unsuccessful. Meanwhile, design specifications on a 10-centimeter air-borne search set called the Rotterdam Gerate had been received by radiotelegraph from Germany. (It now is believed the data came from an early British H2S set shot down by the Germans over Rotterdam.) On the basis of the received data, the navy electronics laboratory set out to build equipment. The result was the number 51, or Pathfinder, set which is roughly equivalent to the American ASG or SCR-717-B. It is a 10-centimeter magnetron powered set with a north stabilized 150-millimeter plan position indicator oscilloscope tube. The magnetron is the M-314, and can be seen inserted inside the toroidal-type magnet in Figure 3. Arrangement is made for a lubber line to show the heading of the airplane at any instant. A second *A*-display tube reads altitude. A small M-60-S magnetron is used as the local oscillator. The antenna is the rotating cut parabola type and carries a folded antenna with a parasitic dipole reflector in front of it. Preliminary flight results showed that shorelines could be distinguished at only 20 kilometers, a figure far below what had been hoped.

NAVY LOCATOR-TYPE RADAR SETS

The first navy ground-based locator-type radar was based on the American SCR-268's captured at Corregidor in the spring of 1942. Research on the resulting S-3 antiaircraft fire control set was begun in August 1942 and concluded a year later. The Sumitomo Company was provided with drawings of the desired equipment from which they produced about 80 sets, at the very slow rate of five per month. The close resemblance of the copy to the original, the American set, may be

Table II. Nihon Musen Magnetron Characteristics

Tube Designation	Tube Characteristics: Anode Voltage	Peak Anode Current	Wave Length (centimeters)	Peak Power Input (kw)	Peak Power Output (kw)	Magnetic Field Gauss
Transmitting:						
M-312	11,000	2.a	9.83–9.92	22 peak	6.6 peak	1,000
M-314	11,000	5.a	9.83–9.92	55 peak	17 peak	1,000
S-60	8,000	7.a	5.2	60 peak	18 peak	2,100
S-51	12,000	6.a	3.15	72 peak	22 peak	2,200
Receiving (beat frequency oscillator):						
M-60	210 ± 20	17 ma ±0.1 (cw)	9.83–9.92	—	—	690
M-2643	540	1.5 ma (cw)	2.8–10.0 (Nominal 3 centimeters)	—	—	4,000

recognized in Figure 4. The Japanese had no better luck with these sets in hitting anything than the United States Forces had with the SCR-268. Meanwhile production was started on a searchlight control set L-1 built along the lines of the British searchlight control data obtained at the fall of Singapore. Attempts also were made to adapt the latter for fire control purposes, resulting in the S-23 set. However, the directional accuracy was not good enough, and after making a few sets, the project was abandoned.

Difficulties in building and maintaining the S-3 resulted in the design of a simpler 200-megacycle anti-aircraft control set known as the S-24. Inasmuch as this set had both greater range and greater accuracy than the S-3, it became the navy's standard land-based fire control radar equipment. However, its accuracy was still very poor as judged by American standards and, with its susceptibility to jamming, it was thoroughly inadequate to handle the pressing anti-aircraft fire control problem.

The navy's initial answer to the jamming problem, as well as the relative inaccuracy of the S-3 and S-24 sets, was to build a higher-frequency set. This was done in the experimental number 61 which, at a wave length of 60 centimeters, has much the appearance of the Small Wurzburg. The navy also had spoken for a share of the production from the army's Wurzburg program.

For ship-borne and coastal defense fire control the navy adapted the number 22 set by switching the receiver alternately to each of a pair of horns with slightly diverging axes. This produced a pair of lobes with a spread of about six degrees. The received signal pips were matched for height on a suitable bearing cathode-ray tube to obtain an azimuthal accuracy in the order of plus or minus one-half degree. Experiments also were made with large parabolic reflectors. Here the dipole antenna was oscillated rapidly in a horizontal slot located roughly at the focus of the parabola.

NAVY GROUND CONTROLLED INTERCEPTION

The navy plan for controlling friendly fighters was quite similar to that proposed by the army. A ground interrogator with broadband antenna enabling it to operate anywhere from 145 to 155 megacycles trips the transponder in the airplane, which replies at a slightly different frequency (up to three megacycles difference). Radar set number 62 obtains range on an *A*-oscilloscope and shows bearing on another oscilloscope by matching pips through a mechanical lobe-switching device. It may be noted that the identification-friend-or-foe transponder in the airplane, when not being employed for ground controlled interception work, sweeps a band of 150 plus and minus five megacycles and replies on the interrogation frequency, so that any 150-megacycle radar set such as the navy's number 13 can identify friendly airplanes by the fluctuating increase of the target return at regular intervals. This corresponds exactly to the old American mark 2 identification-friend-or-foe system. For locating the foe airplane, the navy was developing a long-range (200-kilometers) 100-megacycles-per-second lobe-switching radar set to be called number 63. As with the army's proposed scheme for making interceptions by means of separately tracing the friendly airplane and the foe airplane with radar equipments having relatively poor bearing accuracy, it would seem highly likely that the navy's plan would have given very disappointing results unless exceedingly skillful operators were employed.

The navy was developing two night fighter radars at the time the war ended. The 500-megacycle number FD-2 set had a presentation giving azimuthal corrections only with an oscilloscope indication similar to that of the American SCR-521. The other set, working at 150 megacycles per second, was known as Gyoku-3. It employed an unusual fixed antenna built in two forward-facing layers. By feeding them through a rotating goniometer-type coil, a rotating forward lobe was generated and the corresponding display was shown on a plan position indicator oscilloscope. The definition in this set would seem to be very poor, inasmuch as the beam is some 70 degrees in thickness. Japanese navy engineers insisted, however, that such a thick beam is needed or the entire area in front of the airplane could not be searched adequately. Apparently the idea of rapid scanning by a very narrow forward-looking pencil of radiation had not appeared to them to be practicable.

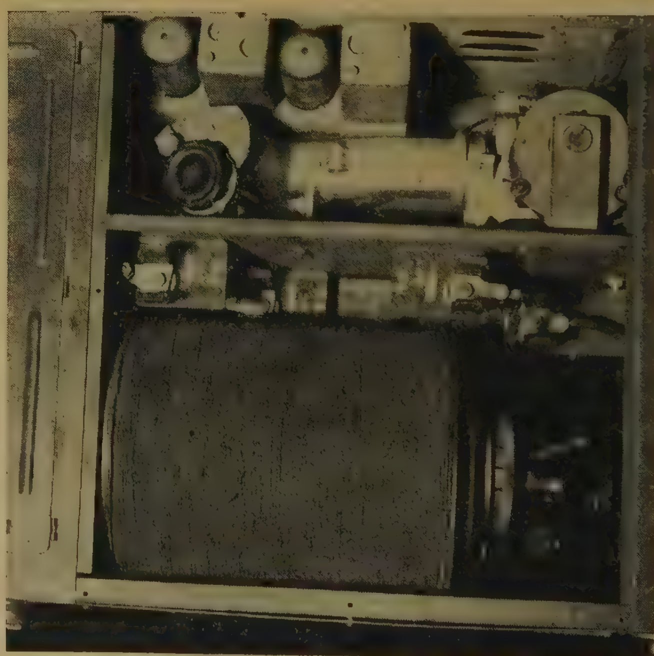


Figure 3. Detail of transmitter of 10-centimeter air-borne "Pathfinder" search set showing electromagnet with magnetron inserted axially

NAVIGATIONAL AIDS

Both the army and the navy had developed low altitude frequency-modulated altimeters, which they claimed had been of good service during low altitude torpedo bombing attacks on enemy shipping. The army also had a high altitude pulsed altimeter, but it gave so much trouble and read so erratically that the flyers would not rely on it. Neither the army nor the navy had any program for vectoring home lost pilots by means of radar plots. No mention of the use of the identification-friend-or-foe sets in the airplanes to extend their locating coverage for this purpose was made in discussions of the various associated equipments.

The army had plans drawn up and equipment partly installed for a simple hyperbolic navigation system very similar to Loran developed by the United States. The idea for this, although denied by the army, was said by navy personnel to have come from Germany. The equipment carried in the airplane was much simpler than in the American version. The radio operator timed, on a stop-watch, the interval taken by a carefully controlled drift pulse from one of the two ground stations to travel between coincidence with the two regular pulses from the ground stations. Very likely the accuracy does not compare with that obtained by American sets, although it may well be good enough to be of great value to airmen.

RADAR MANUFACTURERS

The production of radar equipment for both the army and navy was contracted for by a relatively few large manufacturing concerns, who in turn were supplied with parts and minor assemblies by a myriad of small producers. The method of handling was not unlike that used in the United States. The three principal Japanese radar manufacturers were the Nihon Musen Company, the Tokyo Shibaura Denki, and Sumitomo Tsushin Kohgyoh. Each maintained a staff of electronic research workers recruited mainly from the company's peacetime engineers, physicists, chemists, and metallurgists.

Figure 4. Rear view of S-3 radar (at Chogo)
Note resemblance to American SCR-268

The policy of secrecy enforced by both the Japanese army and navy was a great handicap to production. Often in the same plant similar sets were being developed by company engineers for the two branches of the service, but they were not permitted to exchange the slightest information. For example, the Nihon Musen Company's main plant was divided carefully into two parts, one for manufacturing army equipment and the other for navy equipment. This military policy was criticized strongly by all company officials who saw not only the wastefulness of building two sets to do the same work, but the even more critical loss in engineer and research talent caused by such duplication of design.

The Nihon Musen Company, an affiliate of the German Telefunken electrical interests since 1923, employed some 16,500 workers in its four plants at Mataka (Tokyo suburb), Nagano, Ueda, and Suwa. None of these plants was injured by American bombings. The research section, located at the Mataka plant, had two divisions, one on vacuum tubes which employed 60 scientists and engineers, and one on general matters which employed 40 engineers. Nihon Musen's vacuum tube development under the leadership of engineer Shigeru Nakajima was outstanding. To him is given much credit for the design of the successful magnetrons used in the army and navy's most advanced radar equipment. Experimental magnetrons down to 0.7-centimeter wave length had been built, but their lamp load method of measuring powers was inadequate to determine output at such ultrahigh frequencies.

The principal characteristics of Nihon Musen's later magnetrons are given in Table II.

Perhaps Nihon Musen's most interesting commission was, in 1945, to build as quickly as possible three exact copies of the German Small Wurzburg, known in Japan as Tachi-24. These were to be used as models for building 50 sets by the three large radar manufacturers to fill the first joint order of the army and navy. The first of the models was within one month of completion when the war ended on August 15.

Tokyo Shibaura Denki is the Japanese counterpart of the General Electric Company in the United States, and before the war was affiliated with that company and others for the exchange of certain technical information. The company operated five plants located in Tokyo, Kawasaki, Fuji, and Yobe, with a total of 27,000 employees at their peak of production. The three largest plants which were in the south Tokyo area were estimated to be 70 per cent destroyed by fire and bombings. The general and electronics research laboratories, located in the Koikawa Cho plant both were destroyed completely. The general research section was comprised of 100 engineers and scientists, while the electronics laboratory employed about 150 research workers.

In the Tokyo Shibaura electronics laboratory considerable effort was being expended to produce magnetrons at higher and higher frequencies. A 15-centimeter magnetron for the Tase-2 set was the laboratory's highest frequency tube actually in production. However, the research director, Doctor Hamada, had built experimental all-metal types down to three centimeters. For example three of these models shown in Figure 5 have the following claimed performance:

Three centimeters—1-kw peak (air-cooled).
Five centimeters—3-kw peak (air-cooled).
Nine centimeters—10-kw peak (air- and water-cooled).

In general, electromagnets were used for obtaining a strong field for the magnetrons, although experiments with materials for permanent magnets had yielded fields up to 2,000 gausses. Shortages of nickel and cobalt were given as reasons for not developing the permanent magnet program to a fuller extent.

For local oscillators, Tokyo Shibaura engineers had experimented with positive grid Barkhausen tubes to work with crystal detectors. They had tried to build power klystrons five years or more ago at about 20 centimeters but without much success. More recently they had been working with klystrons for receivers at three, five, and ten centimeters.

The Sumitomo Communications Industries Company in peacetime is Japan's leading manufacturer of telephones and automatic and manual switchboards, as well as much wireless and electric testing equipment. It is owned partly by the International Standard Electric Company. Its seven plants in Japan employed 32,500 persons. About half of these were at the Tamagawa plant in Kawasaki which was about 60 per cent destroyed by bombing. The Ikuta research laboratory, 12 miles southwest of Tokyo, is one of the largest electronics research groups in Japan, with a staff of 650 engineers and assistants. During the war most of the talent was devoted to radar research in one form or another.

In November 1944 Tama Institute directed the Sumitomo Company to develop and build a 5-centimeter air-borne search radar set, with the single specification "with as much power and range as possible." At that time they did not know that the American B-29's were equipped with 3-centimeter radar sets or they might have attempted that wave length. The tube research section finally succeeded in devising a 5-centimeter magnetron with equalizer ring which developed one kilowatt of pulsed power, but not until Tama Institute had made available, early in 1945, several recovered magnetrons from APQ-13 sets in crashed B-29's. (A number of these were in operating condition, although the Japanese never obtained more than five kilowatts from them.) The antenna and radio frequency "plumbing" were influenced considerably by American design. At the same time a velocity modulated tube with variable frequency was developed as a beat frequency oscillator to work in the receiver. The size of the metal cavity clamped or soldered to the flanges passing through the glass envelope determines the resonating frequency, which can be varied up to plus or minus five per cent by mechanically compressing the cavity. The voltage on the repeller is varied until maximum output is obtained.

Figure 5. "Rising Sun" type magnetrons built by Tokyo Shibaura Company

Wave lengths from top to bottom: 9 centimeters, 5 centimeters, and 2.7 centimeters

ARMY-NAVY LIAISON

The great majority of the radar sets installed on the islands which the Japanese invaded were navy types and were operated by navy personnel to protect their own installations. In this way the navy became experienced in early-warning activities near the beginning of the "Pacific War," as the Japanese call it. In the Japanese homeland however, the army was charged with the responsibility for general air raid warning and covered the islands with a network of stations of both types *A* and *B*. There was an almost negligible liaison between the army and navy all the way from research and design through manufacture, installation, and operation. As a result, in Japan proper the navy practically duplicated the army's early-warning coverage, but the information so obtained was used almost exclusively for alerting their own air and sea bases and such antiaircraft and fighter protection as they had available.

The severe loss in efficiency caused by the unwillingness of the two branches of the service to exchange ideas or use any of the same equipment was pointed out strongly by manufacturers, and by others in academic circles who had no military loyalties to defend. The danger of this condition finally was appreciated in certain high quarters, and a joint army–navy committee was set up in August 1943 to correlate the army and navy

Figure 6. The Tokyo Information Center viewed from the outer moat of the Imperial Palace grounds

The bedspring antennas visible are part of an experimental 60-centimeter frequency modulated communications set

programs. Although the committee met once a month, its ineffectiveness is seen by the fact that it could not obtain agreement between the army and the navy even on using the same identification-friend-or-foe set. The navy adopted a set with transponder sweeping from 145 to 155 megacycles, while the army's set in the airplane received at the spot frequency of 184 megacycles and retransmitted at 175 megacycles. Thus the army could not distinguish Japanese navy airplanes from enemy airplanes, nor could the navy do better for the Japanese army airplanes, and the jealousies between the two services were such that neither seemed to care! The chief contributions of the army–navy joint committee seem to have been to unite the two services on ordering of the Small Wurzburg sets and to obtain agreement that the next air-borne set following the navy's number 51 and the army's Taki-14 would be a jointly sponsored 5-centimeter equipment. Some question exists even as to the co-operation present on this last project, inasmuch as, at the close of the war, the army was experimenting actively with 5-centimeter sets (Taki-34) with apparently no participation by the navy.

JAPANESE RADAR COUNTERMEASURES

Both the army and the navy appreciated the need for knowing what manner of radar sets was being used against them. Both had developed a line of search receivers with various means of displaying or recording the signals picked up. Some were equipped with oscilloscope presentations whereby homing on a signal was possible. The army, in addition, had built a pair of "wave disturbers," Taki-8 and Taki-23, which were spot jammers of either the impulse or continuous wave type, covering the wave lengths from 7 meters down to 80 centimeters. A magnetron jammer especially designed for the *X*-band of the B-29's was under construction.

Repeated questioning of army and navy radar engineers brought forth emphatic denials that the Japanese ever had installed a captured American identification-friend-or-foe set in their ships or airplanes. This makes very difficult an explanation of certain observed instances where Allied Forces were sure that their identification-friend-or-foe system had been compromised. The upper end of the navy identification-friend-or-foe M-13 sets' sweep at 155 megacycles nearly would overlap the lower edge of Allied frequencies. However, the Japanese navy maintained that development of this set

Figure 7. View of the north wall of the operations room in the Tokyo Information Center

Visible are part of the ground observer display map, the type A detector display board, and part of each of the banks of ground observer display panels

was completed only in July of 1945, and that of the 50 sets manufactured, none was yet in operational use. The army equipment, with split interrogating and responding frequencies, should not have shown up on American radar equipments at all.

EFFECTIVENESS OF ALLIED JAMMING

According to all accounts, Allied jamming was so effective that, after May 1, 1945, it was impossible for Japanese antiaircraft guns to shoot unless they had visual tracking. This meant that American bombers had to be picked up first by searchlights which themselves were having a great deal of trouble finding the the target because of the very same electronic jamming on their 200-megacycle frequency.

Inquiry revealed that Allied use of "window" (metal foil strips dropped to create phantom targets), while effective, did not cause nearly the difficulty that the electronic jamming produced. Skilled operators at such places as Kobe were able to distinguish airplanes from the false window targets and to give some rough indications of the locations of the airplanes. However, the electronic jamming created a sea of grass over the entire oscilloscope, and it was impossible to distinguish targets of any kind.

RADAR TRAINING

Both the army and the navy had organized radar training schools for operators and maintenance men. The army's school at Tachikawa was equipped fairly well with several of each type of radar set used by army forces, and could accommodate about 1,200 students at one time. Radar operators here received three months of instruction, maintenance men six months. The navy operated a very large and exceedingly well-equipped school at Chogo, just south of Atsugi airdrome. Courses ran from four to ten months for the 7,000 students who could be accommodated at one time. This school compared very favorably with those set up in the United States for the same purpose.

JAPANESE AIR DEFENSE SYSTEM

The Japanese air defense system was an elaborate combination of ground observers and type *A* and *B* radar sets. Partly on that very account, it was unwieldy and slow to function. Certain features of the amazingly complex fighter control centers were conceived and built very well. The display of radar information on a lighted gridded map without the use of cluttering stands, for instance, was good. But the equally important ground observer reports appeared at another location and in a quite different presentation form from which no flight tracks were plotted. In addition, there was the problem of using the data from antiaircraft radar systems which came in over a loudspeaker and were plotted on a third display position. It must have been impossible for an ordinary human controller to co-ordinate and filter in his mind all of the information arriving during a large raid. Figure 6 shows a view of the Tokyo Fighter Control Center, located just inside the outer moat of the Imperial Palace grounds. Japanese military officials flatly denied that the control center had been placed there purposely to increase its immunity to Allied bombs. Whether intentional or not, the effect was the same inasmuch as American forces carefully avoided bombing the palace area. Figure 7 shows part of the operations room.

There was also apparently little or no system by which fighters could be directed properly to get into an advantageous position for making an interception as the B-29's arrived, even though in most cases early warning of an hour or more was available. Very poor liaison was maintained between the army and the navy information centers. It would have been a long step forward to have consolidated the two early-warning systems and to have had all stations report to a single information center in the area. Full information would have been had, then, with half the expense and confusion.

Through the fighter control center means for locating friendly aircraft could have been arranged easily by the simplest of direction finding chains. This method would have aided them greatly in developing the techniques necessary for conducting interceptions well before raiders reached the target. Moreover, it would have provided a means for locating pilots in distress and directing them back to friendly bases. As it was, pilots running out of gasoline over the ocean could not be aided inasmuch as their position was too indefinite to warrant sending out rescue craft. This fact further aggravated the scarcity of good night pilots.

CRITIQUE OF JAPANESE RADAR

All in all, it must be said that the type *A* plus the type *B* equipments gave entirely adequate early warnings of B-29 raids. Occasionally, single bombers flying low and fighters in small formations could slip through the net, but not so often as to present a serious problem. The far-flung system of ground observers tended to fill in any warning shortcomings of the radar equipments.

The good Japanese air raid warning service was useful in that it gave people a chance to seek shelter in time to save their lives. At the same time, the resistance offered to the approaching bombers by antiaircraft fire and by fighter interceptors was pitifully small. This was very largely because the Japanese did not have:

1. Sufficiently accurate fire control radar.
2. Ground and air-borne equipment adequate for ground controlled interception work.
3. An effective system for using what radar they did have of this type.

A considerable part of the responsibility for the poor

showing made in resisting American raids must be attributed to the lack of technical development by the Japanese of radar sets accurate enough for good fire control or for fighter direction, that is, the equivalents of the United States forces SCR-584 and SCR-527 and, of course, the AN/CPS-1 (or MEW).

The men in charge of electronics research in both the Japanese army and navy well were aware of their deficiencies in fire control and air-borne interception radar. They were pressing their own engineers and those of industrial concerns to overcome these gaps in their defenses at the earliest possible moment.

Much of the Japanese-designed radar equipment examined appeared to be crude both electrically and mechanically in comparison with the later United States sets, although certain equipments were constructed beautifully with no skimping on materials. There is some doubt as to whether the Japanese could have duplicated successfully American modern fire control and ground controlled interception radars even if they had captured them. As a matter of fact, they had obtained fairly good specimens of American identification-friend-or-foe sets and the APQ-13 from B-24's and B-29's, but, generally stated, they never had been able to put them into complete operation. Admiral Nawa, head of Japanese navy electronics research, stated that their greatest shortcoming in comparison with American radar design was their inability to turn out a high-powered centimeter transmitting tube. Most students of the situation will agree, although, as has been noted, independent Japanese research was well on the way.

Very severe criticism should be leveled by the Japanese people at those military leaders who insisted for so long that army and navy research, development, production, and operation be kept entirely separated. Equally as serious was the neglect to organize the full scientific power of the nation for war research. All this, of course, is realized now by Japanese ex-military leaders. They would not be likely to commit the same mistake another time.

Report from Bikini

H. H. SKILLING
FELLOW AIEE

An AIEE member who was present at the recent atomic bomb tests at Bikini reports his reactions to the tests to the Institute. Full texts of the reports of President's Evaluation Commission and the Joint Chiefs of Staff Evaluation Board are included.

As ONE of the members of the American Institute of Electrical Engineers invited to witness the atomic bomb tests at Bikini, may I take this means of making a short report to the Institute?

Since returning from Bikini, I most frequently am asked two questions: were the tests worth while, and what are the general indications for the future? The best answers I can give are not my own alone, but reflect my views as influenced by the 22 other American observers in the same group and the 21 observers representing nations of the Security Council of the United Nations.

The tests were very much worth while. Every engineer can appreciate the importance of tests made under conditions as near those of actual practice as feasible. Extrapolation from small-scale tests, or from data gathered under dissimilar conditions, is a helpful guide; but whether the subject is machinery or lightning or atomic bombs, information from full-size tests is of the greatest aid to the designer. It is evident that if the United States is to have a navy at all it must have an effective navy, and it is only reasonable that its military and naval designers should be supplied with all information that can be obtained. If there is to be another major war it will be an atomic war (this is the opinion of our group) and if we are to have a navy it must be prepared to resist atomic weapons.

It must not be thought that the purpose of the tests was to gather data for pure science. This may come as a by-product, but the major object was military and naval information. Plans for the tests were made and carried out carefully, and the records cover not only such obvious factors as pressure and temperature of the blast, but also collateral matters including effect on radio propagation, wave action on the beaches, and possible results on fish feeding on radioactive organisms in the lagoon. Automatic recording equipment was used for a great many purposes, and full interpretation will require a large amount of careful work.

Regarding the future, the atomic bomb is surely a

H. H. Skilling is dean, school of engineering, Stanford University, Stanford University, Calif.

terrific weapon. It is highly destructive through a radius of about 1,000 yards and only very strong structures can survive the shock and heat of the bomb within this distance. A battleship, for example, may not be destroyed at a distance of a few hundred yards, but it will receive considerable damage. Beyond 1,000 yards damage is relatively slight: light structures are thrown down, windows are broken, fires may start in readily inflammable material.

Within 1,000 yards there would be heavy casualties among any persons exposed directly to the blast of a bomb exploded in air, and, in addition, the fatal effects of radioactivity extend 1,000 yards or more from a bomb exploded either in air or water. For the under-water bomb, radioactivity may be serious at a distance of several miles, resulting from drenching with radioactive water.

Excellent statements of the results of the bomb exploded in air may be found in the "Report of the President's Evaluation Commission" and the "Report of the Joint Chiefs of Staff Evaluation Board," both released by President Truman on July 11, 1946. (These reports, in full, are appended to this article.) The observations of our unofficial group are in full agreement with these reports.

Regarding the possibility of maintaining peace, our scientists and military men, both American and from the United Nations, were in very general agreement on a number of points. First, people of each nation must come to know the people of other nations, to understand their problems and their points of view, and to sympathize with their troubles. Then it will be possible to take steps to remove economic and political causes of discord. Then it will be possible for political machinery such as the United Nations organization to be effective.

It was the expressed hope of the group of observers that all educated and enlightened persons will promote good feeling between the people of our country and the people of other countries by all possible means. Effective means mentioned include travel, traveling fellowships, reading, speaking, and whatever may be done to encourage calm and thoughtful interpretation of the daily news. But even in the present state of incomplete understanding and sympathy the United Nations organization is of great value and must be given every support.

Report of the President's Evaluation Commission

Dear Mr. President:

Your Evaluation Commission, divided between positions at sea and in the air, witnessed the first Bikini test, at 33 seconds after 9:00 A.M. local time on July 1, and has since completed a survey of the damage. The second test, wherein the bomb will be exploded under the water, will in some respects be of even greater interest, for it will have no precedent. The report of your Commission required by its directive of May 18 must await assembly of considerable data deriving from instrumental and photographic measurements and analysis of fission product samples. However, we believe that it lies within the scope of your directive and may be of possible assistance to you, to submit, now, the following brief observations made from the layman's point of view, but with such accuracy as is presently available:

The organization and execution of the operation was magnificently handled and has commanded our continuous admiration. The bomb was dropped under favorable weather conditions about 30 seconds after the time set. The greatest credit is due Admiral Blandy and the officers and enlisted personnel of both services who, with scientists and other civilians, have served and are serving under him with a display of team work that must be seen to be fully appreciated.

Their conservatively safe distance from the burst led many observers to entertain an initial opinion that the bomb employed was somewhat under par. It is now, however, safe to state that the energy was of the same order of magnitude as in the case of previous atomic detonations, between the highest and the lowest of this bomb's three predecessors.

The accuracy of the drop was such that the explosion occurred within the area included within the allowance for the probable error of the elevation of drop, and detonation was probably within 100 feet of the chosen altitude. Nevertheless the explosion actually occurred several hundred yards west of a point directly above the target ship Nevada, and therefore entirely west of the closely spaced array of capital ships.

There were 90 targets anchored in the lagoon when the bomb exploded. These were not in battle formation but were placed in positions to give the largest amount of desired technical information with especially close concentration around the center target point. Those ships anchored a mile or more from the point of drop largely escaped injury. Those within a mile were sunk or suffered damage varying with the distance from the point of detonation and with the type of ship construction. On explosion, a destroyer and two transports sank promptly. A second destroyer and the Japanese cruiser Sakawa sank within 27 hours. The light carrier Independence was gutted with fire and resultant explosions. The submarine Skate was damaged heavily and later towed away. All of these were near the point of explosion. The other ships, including the only two capital ships which were within one half a mile of the detonation, received damage that would require more or less complete overhaul and in most cases repair at major bases before they could again be used for combat. A study of this damage will point the way to changes in design which should minimize the damage from blast and heat. Beyond these ships there was extensive damage to superstructure, radar, and fire control. Had the ships within the damage area been manned, casualties and psychological injuries would have required a large percentage of replacements. Until the readings of complex instruments and the future life history of animals within the ships have been determined no accurate appraisal of potential damage to human life within the ships can be made.

No wave or blast damage could be noticed on Bikini Island which is approximately three miles from the point of detonation.

We are of the unanimous opinion that the first test amply justified the expenditure required to conduct it and that the second test is equally desirable and necessary. You made a wise decision when you approved the plans for these tests and they have been carried out with extraordinary skill, diligence, and ingenuity. The test just completed has again proved that the atomic bomb is a weapon of terrific power when used on land or sea.

Most respectfully yours,

Carl A. Hatch, chairman for the committee

Report of the Joint Chiefs of Staff Evaluation Board

In compliance with a directive from the Joint Chiefs of Staff dated 27 February 1946, the Evaluation Board presents the following preliminary report of the atomic bomb test *A* held at Bikini Atoll on 1 July 1946. This report covers general observations only. Detailed evaluation must await full collection and analysis of data from observers and instruments and will be reported at a later date.

The members of the board inspected target ships the day before the test, witnessed the explosion from an airplane 20 miles distant, and then approached to within nine miles of the atoll for a brief view. On the following day, as soon as safety clearance had been received, the members flew to Bikini and began their examination of ship damage. Many photographs have been studied, and military and scientific specialists interviewed, in an attempt to obtain an over-all understanding of test results prior to the compilation of all the data.

From its previous study of the plans for the test, and from its observations in the Bikini area, the board considers that the test was well conceived and executed by the services in close co-operation with a large civilian staff. It is satisfied that the conditions of the test were well chosen and that the highest skill and ingenuity have been used to obtain a maximum amount of data in an unbiased, scientific manner. It believes that the commander, staff, and personnel of Task Force One deserve high commendation for their excellent performance and their notably co-operative spirit.

Effective precautions appear to have been taken to safeguard personnel against radioactivity and associated dangers.

The board's present information is that the bomb exploded, with an intensity which approached the best of the three previous atomic bombs, over a point 1,500 to 2,000 feet westerly of the assigned target, and at approximately the planned altitude.

The target array in no sense represented an actual naval disposition, but was designed to obtain the maximum data from a single explosion. The most important effects produced by the bomb are the following:

(*a*). A destroyer and two transports sank promptly and another destroyer capsized. It later sank, and the Japanese cruiser Sakawa sank the following day. The superstructure of the submarine Skate was so badly damaged as to make it unsafe to submerge the vessel. The light carrier Independence was badly wrecked by the explosion, gutted by fire, and further damaged by internal explosions of low order, including those of torpedoes. All the afore-mentioned vessels were within one half mile of the explosion point.

(*b*). Numerous fires were started on other ships, including one on a ship two miles distant, which was apparently due to some unusual circumstance, since the other fires were much closer. Here it should be remembered that the target ship decks carried a great variety of test material not ordinarily exposed on the decks of naval vessels.

(*c*). The only major combatant ships within one half mile of the explosion were the battleships Nevada and Arkansas and the heavy cruiser Pensacola. The blast struck these from the after quarter. Apparently little damage was done to their hulls or their main turrets but their superstructures were badly wrecked. These ships were unquestionably put out of action and would, along with many others within three quarters of a mile, have required extensive repairs at a principal naval base.

(*d*). Other ships in the target array suffered damage in varying degree, depending on position and type of ship, but there was relatively little damage at distances greater than three quarters of a mile.

(*e*). The primary material effects noted were due to blast; buckling of decks and bulkheads, and destruction or deformation of lightly constructed exposed objects, including stacks, masts, and antennas. Secondary effects were due to fire, and it is noteworthy that Army Quartermaster stores and miscellaneous equipment placed on the decks for the test proved more vulnerable than normal naval deck gear. It should be pointed out that since the targets carried no personnel the fires were uncontrolled and undoubtedly there was more damage than there would have been under battle conditions. Singularly, although considerable amounts of explosive ordnance were exposed on decks and in gun turrets, there is no indication on ships which remained afloat that any of this material was exploded by direct action of the atomic bomb. Fire fighting ships entered the target area as soon as they could obtain radiological security permission and subdued a number of fires. The speed and efficiency with which these ships acted preserved for later examination a great deal of evidence of bomb action which might otherwise have been lost.

(*f*). Examination of the flash burn effects produced by the initial radiation from the explosion indicates that casualties would have been high among exposed personnel. However, it is the opinion of the board that persons sheltered within the hull of a ship or even on deck in the shadow of radiation from the bomb would not have been immediately incapacitated by burns alone, whatever might have been the subsequent radiological effects.

(*g*). Within the area of extensive blast damage to ship superstructures there is evidence that personnel within the ships would have been exposed to a lethal dosage of radiological effects.

Personnel casualties due to the blast would no doubt have been high for these in exposed positions on vessels within a half mile of the target center. Beyond this any discussion of the blast effect upon personnel will have to await the detailed reports of medical specialists.

In general no significant unexpected phenomena occurred, although the test was designed to cope with considerable variation from predictions. There was no large water wave formed. The radioactive residue dissipated in the manner expected. No damage occurred on Bikini Island, about three miles from the explosion center.

From what it has seen and from what it has ascertained from data now available, the board is able to make certain general observations:

(*a*). The atomic bomb dropped at Bikini damaged more ships than have ever before been damaged by a single explosion.

(*b*). The test has provided adequate data of a sort necessary for the redesign of naval vessels to minimize damage to superstructures and deck personnel from this type of bomb. Because of the nature of the first test (air burst) little information has been obtained on hull effects. Damage to ships hulls will be studied specifically in the second test when a bomb will be exploded under water.

(*c*). A vast amount of data which will prove invaluable throughout scientific and engineering fields has been made available by this test. Once more the importance of large-scale research has been dramatically demonstrated. There can be no question that the effort and expense involved in this test has been amply justified both by the information secured and by greatly narrowing the range of speculation and argument. Moreover, it is clear to the board that only by further large scale research and development can the United States retain its present position of scientific leadership. This must be done in the interests of national safety.

The board desires to say that it has had the fullest co-operation of the Task Force commander, and that every opportunity has been afforded it in carrying out its mission. The members of the board have had access to all data thus far accumulated and have had every facility for personally inspecting the results of the test.

Karl T. Compton, chairman

Statistical Methods in Quality Control

XI. Statistical Tests of Significant Differences

INVARIABLY WE HAVE a limited sequence or set of observed values for each condition of interest, and inferentially some information regarding the parent universe, that is, the underlying distributive pattern that might appear with indefinitely repeated observation. It has been demonstrated, however, that even controlled processes and procedures do not provide identical repetitive results, due to a large number of small unidentifiable causes here referred to as chance causes. Such controlled pattern of variability follows some statistical law of distribution, as illustrated by $f(X)$ in Figure 1. An inference drawn from a finite sample of observations is a prediction of what would be found by indefinite repetition, and involves a degree of confidence, qualified by the chance or sampling error present. But if conditions are not controlled or constant, that is, assignable or identifiable causes of inconsistence are present, inferences based upon statistical laws lose their validity. Such control will be assumed to exist in the following discussion.

Statistical control of repeated operations has been discussed in previous articles of this series. Another problem of common occurrence is the statistical interpretation of limited experimental tests. These tests usually are designed to judge whether or not two comparative conditions provide an actual difference in some quality characteristic.

SAMPLE STATISTICS

It will be recalled that the relevant statistical information in a homogeneous set of n measurements usually can be summarized by:

(*a*). An average or mean $(\bar{X})$, as a location or center of gravity statistic.
(*b*). A standard deviation (σ).

a measure of dispersion about the average. The latter is the root-mean-square of the deviations of individual values from the group average,[1] defined and calculated for a sample of n values as follows:

$$\sigma=\sqrt{\frac{\Sigma_i(X_i-\bar{X})^2}{n}}=\frac{1}{n}\sqrt{n\Sigma_i X_i^2-(\Sigma_i X_i)^2}$$

where ΣX is the sum of the individual values, and ΣX^2 is the sum of their squares. The corresponding statistical characteristics of the parent universe or long-run distribution of individuals, will be indicated herein by primes, as $\bar{X}'$ and σ'.

SIGNIFICANT LIMITS FOR THE SINGLE SAMPLE MEAN

Most practical to project is the chance variability of the means $(\bar{X})$ for repeated samples of size n. Suppose that conditions provide a universe of individuals distributed as function $f(X)$ in Figure 1, with standard deviation σ' about a universe mean $\bar{X}'$. A first sample under such conditions might have mean $\bar{X}_1$, a second same $\bar{X}_2$, and so on, all differing by chance or sampling error.[2] These, in the long run, would be distributed as function $f(\bar{X})$ in Figure 1 about the universe mean $\bar{X}'$, with a standard deviation of means, $(\sigma'/\sqrt{n})$.

Further in such case of means, we well can establish upper and lower symmetrical limits $\bar{X}_L$, beyond which an observed mean for given sample size rarely would fall by chance alone, if the visualized universe existed. These are shown in Figure 1, where the sum P of the selected "tail area" probabilities, P_1 and P_2, represents the risk of a mean falling outside the given range by sampling alone. Such limits usually are expressed as distances from average expectation $\bar{X}'$, in terms of standard deviation units T, as $\bar{X}'\pm T(\sigma'/\sqrt{n})$. In practice we rarely know the exact distributive form of universe at hand, and cannot project precise probabilities and limits for the various statistics used. However, we do know that only a small limiting proportion of observed sample values can fall outside limits calculated with a fairly large T, say of the order of 2.5 or 3.0*. Usually, however, information regarding the standard deviation must be obtained from the sample. With

One of a series of articles prepared in the AIEE subcommittee on educational activities and sponsored by the AIEE subcommittee on statistical methods.

Personnel of the AIEE subcommittee on educational activities: J. Manuele, H. F. Dodge, A. I. Peterson, and R. E. Wareham.

* Although statisticians often assume some theoretical distribution law and deduce limits based upon refined standards for P, say 0.001, engineers often use a more rational approach with $T=3.0$. With the theoretical normal curve model of error, $T=3.29$ is associated with $P=0.001$, and $T=2.58$ with $P=0.01$.

reasonably general confidence we then, in place of T, use a corresponding function known as "student's t," for small samples. Limits for means then would be calculated as

$$\bar{X}_L = \bar{X}' \pm t(\sigma/\sqrt{n-1})$$

where σ is observed in the sample. The values of t are numerically larger than T in comparable cases, to allow for the sampling error now present in the sample values of σ. Tables of t are generally available in texts, for given levels of P, and for various degrees of freedom n', here equal to one less than the sample size, for instance, $n' = n-1$. An extract from such table, for the case of $P = 0.01$, is as follows:

Degree of Freedom n'	Values of Student's t
3	5.84
4	4.60
8	3.36
30	2.75
Infinite	2.58

With an "allowable" t from the table, we project our limits in the case where some standard of expected value $\bar{X}'$ is assumed; then observe whether or not our observed mean conforms to the sampling error range defined.

A more direct approach with the same end calculates the number of standard deviation units, T_0 or t_0, in the observed difference between sample mean $\bar{X}$ and expected mean $\bar{X}'$; then compares this with an "allowable" T or t, corresponding to a chosen level of significance or risk P. The calculations would be as follows:

$$T_0 = (\bar{X} - \bar{X}')/(\sigma'/\sqrt{n})$$

or

$$t_0 = (\bar{X} - \bar{X}')/(\sigma/\sqrt{n-1})$$

Assume that somehow, by exhaustive and controlled repetition, a lot of metal filament has had its true mean strength substantially identified as $\bar{X}' = 14.00$ ounces. It is suspected that an added given treatment will increase the strength. A random selection from the same lot is treated and tested, providing say only five readings with sample $\bar{X} = 15.70$ ounces and $\sigma = 0.75$ ounce. As a conventional working hypothesis, we approach our inference with the view that no change should result, that is, we use a null-hypothesis. Now assume that the level of risk chosen is $P = 0.01$, the afore-mentioned table giving an "allowable" value of $t = 4.60$, for a sample with degrees of freedom $n' = 5-1 = 4$. The sample value calculated is

$$t_0 = (15.70 - 14.00)/(0.75/\sqrt{5-1})$$
$$= +4.53$$

Since the observed t_0 is numerically less than the allowable t, it has been conventional to consider that the observed difference could have arisen by chance alone. We are not inclined, therefore, to reject the hypothesis. But we are by no means in a position to consider the null-hypothesis proved, a point made clearer in the following. The limitations of single small samples are obvious. Further, alternative values just inside and outside any arbitrary extreme limit are not greatly different logically, since both are sufficiently extreme in the same direction, and still leave some doubt as to a conclusive chance explanation. The use of a larger sample would have narrowed the zone of doubt to be differentiated in original units measured.

SIGNIFICANT DIFFERENCES BETWEEN TWO MEANS

Another common case is a comparison of the means of two samples, approached by a similar working hypothesis. Two samples are tested, the second possibly differing because of the test condition changed for comparison (for the added treatment in the foregoing problem). We now have two sample means, $\bar{X}_1$ and $\bar{X}_2$, and two standard deviations, σ_1 and σ_2. The null-hypothesis is that both have the same true universe

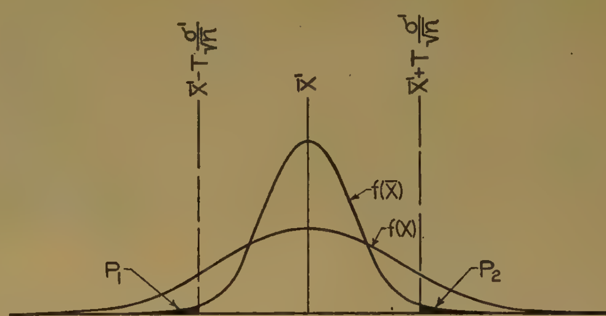


Figure 1

mean, that $\bar{X}_1' - \bar{X}_2' = 0$. Subject to a test not discussed in this article, it is assumed that both have the same true standard deviation, and that the question to be answered lies only in some possible difference in the means.

We then calculate the observed value of t as follows:

$$t_0 = (\bar{X}_1 - \bar{X}_2)/\sigma_{\bar{X}_1 - \bar{X}_2}$$

where the denominator represents the standard deviation of the difference in two means, given from the sample

$$\sigma_{\bar{X}_1 - \bar{X}_2} = \sqrt{\left(\frac{n_1\sigma_1^2 + n_2\sigma_2^2}{n_1+n_2-2}\right)\left(\frac{n_1+n_2}{n_1 n_2}\right)}$$

The allowable t again is found in the student's t tables, but for degrees of freedom now equal to (n_1+n_2-2). The observed t_0 is compared with the "allowable" t as before.

For example, assume two test samples of five each

taken at random from the same lot of material, one to be tested for tensile strength after an added treatment, the other tested untreated. The sample results were

$\bar{X}_1=14.15$
$\bar{X}_2=13.05$
$\sigma_1=0.82$
$\sigma_2=0.65$

The "allowable" value of t; for $(5+5-2)=8$ degrees of freedom and $P=0.01$, is $t=\pm 3.36$. The observed value of t calculations is

$$\sigma_{\bar{X}_1-\bar{X}_2}=\sqrt{\frac{5(0.67^2)+5(0.42^2)}{5+5-2}\left(\frac{5+5}{(5)(5)}\right)}$$

$$=0.523$$

$$t_0=\frac{14.15-13.05}{0.523}=2.50$$

The observed value 2.50 is well within the "allowed" value 3.36, and the apparent difference is considered possibly due to chance. The null-hypothesis cannot yet be considered untenable.

LARGE SAMPLES

When sample sizes are "large," by definition greater than 30, we generally neglect the adjustments for degrees of freedom, and use the T values first mentioned in place of student's t. This is a practical expedient, since we note in the afore-mentioned table that the allowable t values begin to approach the corresponding T values.* In larger samples the difference is even smaller. In the foregoing examples, for the single mean and for two means, the calculations using standard deviations from the samples are

$$T_0=(\bar{X}-\bar{X}')/(\sigma/\sqrt{n})$$

or

$$T_0=(\bar{X}_1-\bar{X}_2)/\sigma_{\bar{X}_1-\bar{X}_2}$$

where

$$\sigma_{\bar{X}_1-\bar{X}_2}=\sqrt{\left(\frac{n_1\sigma_1^2+n_2\sigma_1^2}{n_1+n_2}\right)\left(\frac{n_1+n_2}{n_1n_2}\right)}$$

The allowable T in either case might be taken as 2.58, for $P=0.01$, or can be selected for other P levels from tables of the normal distribution.*

LIMITATIONS

The foregoing techniques, illustrated for means only, generally have been called tests of significance. They have been useful disciplines in experimental development, but also have been misused through superficial generalization and enthusiasm.

We have demonstrated limits for sampling error based upon some level of risk P, for judging the "significance" of a departure from a reference condition. This P is called an "error of the first kind." It is a risk of rejecting the no-change hypothesis by chance, when actually true, that is, of concluding in error that a change from the reference condition has occurred.

However, it is critically important to note again that the alternative appearance of an observed result within such limits cannot be taken as equally valid evidence that no true change has occurred. Figure 2 reconstructs the sampling distribution of means of Figure 1, around the reference value $\bar{X}'$. If, conceivably, the true mean

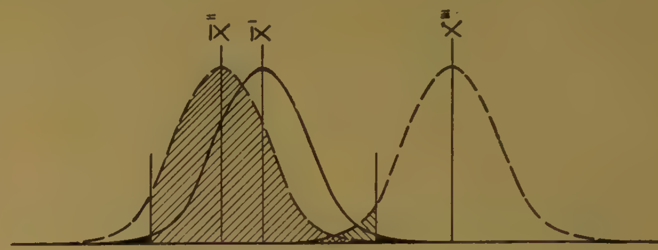


Figure 2

after treatment actually had changed by a relatively slight amount, say to position $\bar{X}''$, the shaded portion of a distribution shown at this position indicates the large chance that a sample mean would have of falling within the originally projected limits in any circumstances. Further, this is true in varying degree for many other possibly true means within a linear region out to $\bar{X}'''$ on either side, where the shading has dropped to a low value. We now can appreciate by illustration that there can be a very real risk of an "error of the second kind"; that of accepting a null-hypothesis when it is false.

There are many difficulties in constructing simple tests that reflect both types of allowable error, and their discussion is far beyond the scope of this article. However, when only a small sample is available, the foregoing technique is of some help, in that we avoid conclusions masked by a range of sampling error inherent to the operation. A nonsignificant difference holds the null-hypothesis in suspense as "not disproved," rather than "proved." Repetitions of such test of course will provide further information, particularly if the relative frequencies with which results fall below, within, and above their limit range interval are compared with expected relative frequencies.

It is evident, of course, that even with the simple methods, the range of uncertainty can be reduced numerically by employing a larger sample.

* The normal distribution integral, or areas from the mean to various numbers of standard deviations, is available in practically all statistics textbooks. It can be noted that the T values of the normal distribution correspond to student t values for infinite degrees of freedom.

REFERENCES

1. Statistical Methods in Quality Control—II. *Electrical Engineering*, volume 64, July 1945, pages 249–50.

2. Statistical Methods in Quality Control—V. *Electrical Engineering*, volume 64, October 1945, pages 363–4.

INSTITUTE ACTIVITIES

Industrial Subjects Featured on Great Lakes Meeting Program

The Great Lakes District meeting to be held in Indianapolis, Ind., October 9–11 is sponsored jointly by the Fort Wayne and Central Indiana Sections. Meeting headquarters will be in the Claypool Hotel. As this District covers a large industrial area, a considerable portion of the program deals with industrial problems. Special attention is called to the general meeting Thursday afternoon conducted by the committee on planning and co-ordination. This conference will be a continuation of similar meetings held at the winter convention, summer convention, and at several District meetings, and everyone is urged to attend.

TECHNICAL SESSIONS

During the three days of the meeting, seven technical sessions and conferences will be held on the following subjects: electric machinery, electronics, power transmission and distribution, industrial power applications, communications, industrial control, and basic sciences.

INSPECTION TRIPS

On Friday afternoon inspection trips will be made to the following power stations and industries:

Marmon Herrington Company in Indianapolis is long established in the automotive industry as a builder of special mobile transportation equipment and lately has started the manufacture of all-electric-drive trolley coaches of modern design.

The Esterline-Angus Company, Inc., in Speedway City has long been recognized throughout the industry in the development and manufacture of quality recording instruments with universal applications to many problems.

Eli Lilly and Company, manufacturer of medicinal products, has its home office in Indianapolis. In its plant may be seen the application of science to the production of medicine. Perhaps no industrial plant requires a greater diversity of equipment or embraces in its personnel a wider range of technical knowledge and skill.

Public Service Company of Indiana, Inc., has at its Lenore substation, Indianapolis, an interesting central power dispatching station for its entire system with associated carrier-current telemetering, carrier-frequency control, and relaying.

Indianapolis Power and Light Company's Harding Street station, is the main source of Indianapolis power supply. Its present rated capacity is 111,000 kw, provided by two units installed in 1931 and a third in 1941–42. A fourth unit similar to the third, with a 37,500-kw turbogenerator and a steam generator capable of delivering 400,000 pounds per hour at 875 pounds pressure and 900 degrees Fahrenheit temperature, is under installation. Exhibited at this plant is the first Curtiss turbogenerator to go into commercial operation, at Newport, R. I., in 1903.

EXHIBITS

Concurrently with the meeting a few appropriate exhibits will be established on the mezzanine floor of the Claypool Hotel. For information on exhibit space refer to J. L. Wright, Jr., 4241 Melbourne Road, Indianapolis.

ENTERTAINMENT

A banquet will be held at 6:30 p.m., Thursday, October 10, in the Riley Room of the Claypool Hotel. An entertainment program for the women also will be provided.

HOTEL ACCOMMODATIONS

The hotel and registration committee is handling reservations for the Claypool Hotel, meeting headquarters. Reservations should be made by addressing S. C. Leibing, chairman, 301 Traction Terminal Building, Indianapolis 4, Ind. The Clay-

Harding Street plant of Indianapolis Power and Light Company with construction work for fourth unit shown at right

Large electric stripping shovel at Ayrshire Collieries Corporation, to which an inspection trip will be made during the Great Lakes District meeting

pool Hotel has reserved 200 rooms. The rates are:

Single bed—$2.75, $3, and $3.50.
Double bed—$5.50.
Twin beds—$6, $7.15, and $7.70.

Those desiring room reservations should write promptly, indicating the rate of room desired and the number of occupants in one party. Due to present-day conditions those desiring rooms are urged to apply immediately. Confirmation will be sent by postcard, if desired.

ADVANCE REGISTRATION

Please register in advance. This will save time at the registration desk. A registration fee of $2 will be charged nonmembers except Student Members and the immediate families of members.

COMMITTEE

F. H. Fleischer and S. C. Leibing are cochairmen of the meeting committee. Subcommittee chairmen are:

C. M. Summers, *meetings and papers;* S. C. Leibing, *entertainment, hotels, and registration;* J. L. Wright, Jr., and S. A. Zimmermann, cochairmen, *publicity and exhibits;* C. E. Chatfield, *inspection trips;* E. R. Linke, *finance;* S. J. Winge, *student activities.*

Technical Program and Meeting Features

● **PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.**

● **ABSTRACTS of numbered papers appear on page 471 of this issue.**

● **PRICES and instruction for procuring advance copies of these papers will accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers will be available in pamphlet form.**

Wednesday, October 9

8:30 a.m. Registration

9:45 a.m. Opening session

S. C. Leibing, presiding

Welcome: The Honorable **Robert H. Tyndall**, Mayor of Indianapolis

Announcements

10:00 a.m. Electric Machinery

M. S. Oldacre, presiding

46-202. Asynchronous and Single-Phase Operation of Synchronous Machines. **A. W. Rankin**, General Electric Company

DP.* Fractional Horsepower Motors for Operation on Thyratrons. **W. R. Goss, F. T. Carlson**, General Electric Company

DP.* Properties of Magnet Wire. **H. A. Smith**, General Electric Company

CP.† New NEMA Fractional Horsepower Motor Standards: Their Effect on Refrigeration and Pump Application. **C. P. Potter**, Wagner Electric Corporation

2:00 p.m. Electronics

O. W. Livingston, presiding

DP.* Electronics in Measurements. **R. J. Kryter**, Esterline-Angus Company

46-203. Frequency Performance of Thyratrons. **H. H. Wittenberg**, RCA Manufacturing Company

DP.* Microwave Magnetrons. **F. F. Reike**, Purdue University

CP.† Electron and Ion Beam Instruments. **G. W. Dunlap**, General Electric Company

2:00 p.m. Power Transmission and Distribution

F. V. Smith, presiding

DP.* Simplicity in Transformer Protection. **E. T. B. Gross**, Illinois Institute of Technology

DP.* Rural Electrification in Iowa. **C. M. Stanley**, Stanley Engineering Company

DP.* Experience With Single-Pole Relaying and Reclosing on a Modern 132-Kv System. **J. J. Trainor, C. E. Parks**, Public Service Company of Indiana

DP.* Calculation of Power System Losses by Formula Using Constants Determined by the Network Analyzer. **J. B. Ward**, Purdue University

CP.† Trends in Rural-Line Sectionalizing. **R. F. Quinn**, General Electric Company

Thursday, October 10

9:30 a.m. Industrial Power Applications

L. A. Umansky, presiding

CP.† Multiple Generator for Paper Machines. **G. E. Plaisted**, General Electric Company

CP.† Lightning Protection for Industrial Plants. **E. W. Beck, J. Z. Linsenmeyer**, Westinghouse Electric Corporation

CP.† Automatic Contouring Control. **J. M. Morgan**, General Electric Company

CP.† Demonstration of Industrial Distribution Systems. **H. G. Barnett**, Westinghouse Electric Corporation

9:30 a.m. Communications

J. J. Pilliod, presiding

DP.* Manufacturing Problems of Air-Borne Transmitter Equipment. **J. A. Green**, Collins Radio Company

DP.* Phenomenon of Microwaves (demonstration). **H. R. Gruelle**, Indiana Bell Telephone Company

46-204 ACO.** Analysis of Four-Terminal Networks Containing Vacuum Tubes. **W. R. Abbott**, Iowa State College

DP.* Mobile Radiotelephone Service. **J. G. Harden**, Indiana Bell Telephone Company

46-205. A Multichannel Microwave Radio Relay System. **H. S. Black, J. W. Beyer, T. J. Grieser, F. A. Polkinghorn**, Bell Telephone Laboratories, Inc.

2:00 p.m. Discussion on the Organization of the Engineering Profession

T. G. LeClair, presiding

The conference will be devoted to discussion of activities of the committee on planning and co-ordination, including organization of the engineering profession as a whole and discussion of the four proposed plans of organization. Following the discussion the members will be given an opportunity to record their opinions of the plans for the guidance of the professional activities subcommittee in their further consideration of the organization problem.

6:30 p.m. Banquet

T. G. LeClair, presiding

Address: Nature and Implications of Atomic Energy. **Doctor Frank H. Spedding**

Doctor Spedding is a member of the Manhattan District Declassification Committee. This is the national committee that has been set up to recommend what scientific information obtained during the war in connection with atomic research can be released at this time in order to aid in the progress of scientific development. Doctor Spedding was flown to and from the Pacific in order to witness the Bikini tests.

Friday, October 11

9:30 a.m. Industrial Control

R. W. Jones, presiding

CP.† Trends in Co-ordinated Control. **G. A. Moffett**, General Electric Company

DP.* Control of Slip-Ring Motors by Means of Unbalanced Primary Voltages. **N. L. Schmitz**, Cutler-Hammer, Inc.

DP.* Problems in Design of A-C Magnets and Solenoids. **L. T. Rader**, Illinois Institute of Technology

9:30 a.m. Basic Sciences

K. W. Miller, presiding

CP.† The Electronic Numerical Integrator and Computor. **T. K. Sharpless**, University of Pennsylvania

CP.† Radioactive Isotopes and Their Application. **G. Freidlander**, General Electric Company

DP.* Latest Developments in High-Energy Physics. **Karl Lark-Horovitz**, Purdue University

DP.* Solar Electron Radiation and Its Effect on Power Transmission and Communications. **J. T. Wilson**, Allis-Chalmers Manufacturing Company

12:30 p.m. Luncheon and Meeting of Great Lakes District executive committee

1:30 p.m. Inspection Trips

*DP: District paper; no advance copies are available; not intended for publication in *Transactions.*

†CP: Conference paper; no advance copies are available; not intended for publication in *Transactions.*

**ACO: Advance copies only available; not intended for publication in *Transactions.*

AIEE Officers to Be Nominated for 1947 Election

For the nomination of officers to be voted upon in the spring of 1947, the AIEE nominating committee will meet in New York, N. Y., in January 1947. The officers to be elected are: a president, a treasurer, three directors, and five vice-presidents, one from each of the even-numbered geographical Districts. Fellows only are eligible for the office of president, and Members and Fellows for the offices of vice-president, director, and treasurer.

To guide this committee in performing its constituted task, suggestions from the membership are, of course, highly desirable. To be available for the consideration of the committee, all such suggestions must be received by the secretary of the committee at Institute headquarters, not later than December 15, 1946.

In accordance with the provisions in the constitution and bylaws, as amended during 1935 and quoted in the following paragraphs, actions relating to the organization of the nominating committee are now under way.

Constitution

28. There shall be constituted each year a nominating committee consisting of one representative of each geographical District, elected by its executive committee, and other members chosen by and from the board of directors not exceeding in number the number of geographical Districts; all to be selected when and as provided in the bylaws. The secretary of the Institute shall be the secretary of the nominating committee, without voting power.

29. The executive committee of each geographical District shall act as a nominating committee of the candidate for election as vice-president of that District, or for filling a vacancy in such office for an unexpired term, whenever a vacancy occurs.

30. The nominating committee shall receive such suggestions and proposals as any member or group of members may desire to offer, such suggestions being sent to the secretary of the committee.

The nominating committee shall name on or before January 31 of each year, one or more candidates for president, treasurer, and the proper number of directors, and shall include in its ticket such candidates for vice-presidents as have been named by the nominating committees of the respective geographical Districts, if received by the nominating committee when and as provided in the bylaws; otherwise the nominating committee shall nominate one or more candidates for vice-president(s) from the District(s) concerned.

Bylaws

Sec. 22. During September of each year, the secretary of the nominating committee shall notify the chairman of the executive committee of each geographical District that by December 15 of that year the executive committee of each district must select a member of that District to serve as a member of the nominating committee, and shall by December 15, notify the secretary of the nominating committee of the name of the members elected.

During September of each year, the secretary of the nominating committee shall notify the chairman of the executive committee of each geographical District in which there is or will be during the year a vacancy in the office of vice-president, that by December 15 of that year a nomination for a vice-president from that District, made by the District executive committee, must be in the hands of the secretary of the nominating committee.

Between October 1 and December 15 of each year, the board of directors shall choose 5 of its members to serve on the nominating committee and shall notify the secretary of that committee of the names so selected and shall also notify the 5 members selected.

The secretary of the nominating committee shall give the 15 members so selected not less than 10 days' notice of the first meeting of the committee, which shall be held not later than January 31. At this meeting, the committee shall elect a chairman and shall proceed to make up a ticket of nominees for the offices to be filled at the next election. All suggestions to be considered by the nominating committee must be received by the secretary of the committee by December 15. The nominations as made by the nominating committee shall be published in the March issue of *Electrical Engineering* (Journal of AIEE), or otherwise mailed to the Institute membership not later than the first week in March.

INDEPENDENT NOMINATIONS

Independent nominations may be made in accordance with provisions in article VI, section 31, of the constitution and section 23 of the bylaws, which are quoted below:

Constitution

31. Independent nominations may be made by a petition of twenty-five (25) or more members sent to the secretary when and as provided in the bylaws; such petitions for the nomination of vice-presidents shall be signed only by members within the District concerned.

Bylaws

Sec. 23. Petitions proposing the names of candidates as independent nominations for the various offices to be filled at the ensuing election, in accordance with article VI, section 31 (constitution), must be received by the secretary of the nominating committee not later than March 25 of each year, to be placed before that committee for the inclusion in the ballot of such candidates as are eligible.

On the ballot prepared by the nominating committee in accordance with article VI of the constitution and sent by the secretary to all qualified voters during the first week in April of each year, the names of the candidates shall be grouped alphabetically under the name of the office for which each is a candidate.

(*Signed*) H. H. Henline,
Secretary

Winter Meeting Committees Appointed for 1947 and 1948

Announcement of the members of the winter meeting committees for 1947 and 1948 has been made by AIEE President J. E. Housley. The committee for the 1947 winter meeting, which will be held in New York, N. Y., as is customary, will be:

C. S. Purnell, *chairman;* W. J. Barrett; O. E. Buckley; P. C. Cromwell; M. D. Hooven, R. A. Jones; A. E. Knowlton; J. H. Pilkington.

The committee for the 1948 winter meeting to be held in Pittsburgh, Pa., is:

C. A. Powel, *chairman;* C. T. Sinclair, *vice-chairman;* L. N. Grier, *secretary-treasurer;* H. S. Fitch; Paul Frederick; J. R. MacGregor; and A. C. Monteith.

Lamme Medal Nominations Due December 1, 1946

Attention is called again to the opportunity open to any Institute member to submit nominations for the 1946 AIEE Lamme Medal. All nominations must be received not later than December 1. For further particulars see *Electrical Engineering*, July 1946, page 330.

The 1945 medal was awarded to David C. Prince, vice-president, general engineering and consulting laboratory, General Electric Company, Schenectady, N. Y. An account of the presentation of the medal to him was published in the October 1946 issue of *Electrical Engineering*, page 435.

Future AIEE Meetings

Great Lakes District Meeting
Indianapolis, Ind., October 9–11, 1946

Winter Meeting
New York, N. Y., January 27–31, 1947

North Eastern District Meeting
Worcester, Mass., April 23–25, 1947

Summer Meeting
Montreal, Quebec, Canada, June 9-13, 1947

Additional Member for Life. The name of Claude A. Jagger (A '11) engineer of the control engineering division, General Electric Company, Schenectady, N. Y., was omitted from the list of new members for life published in the July 1946 issue of *Electrical Engineering*, page 352. Mr. Jagger's status as an AIEE member for life became effective November 1, 1945.

Lightning Handbook in Preparation. The lightning and insulator subcommittee of the AIEE committee on power transmission and distribution has announced that volume II of the "AIEE Lightning Reference Book" is nearing completion. It is expected that the second volume will be the same size as the first—about 1,500 pages. Besides including approximately 200 articles, the book will contain an index of more than 200 additional articles for reference only. The book will be for sale on a nonprofit basis, and the subcommittee is endeavoring to insure a supply which will meet the expected large demand.

ABSTRACTS. . . .

TECHNICAL PAPERS previewed in this section will be presented at the AIEE Great Lakes District meeting, Indianapolis, Ind., October 9–11, 1946, and will be distributed in advance pamphlet form as soon as they become available. Copies may be obtained by mail from the AIEE order department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstract; or at five cents less per copy if purchased at AIEE headquarters or at the meeting registration desk.

Mail orders will be filled AS PAMPHLETS BECOME AVAILABLE

Communication

46-205—A Multichannel Microwave Radio Relay System; *H. S. Black (F '41), J. W. Beyer (M '36), T. J. Grieser, F. A. Polkinghorn (M '39). 25 cents.* An eight-channel microwave relay system is described. Known as AN/TRC-6, the system uses radio frequencies approaching 5,000 megacycles. At these frequencies, there is a complete absence of static and most man-made interference. The waves are concentrated into a sharp beam and do not travel along the earth much beyond seeing distances. Other systems using the same frequencies can be operated in the near vicinity. The transmitter power is only

1/4,000,000 as great as would be required with nondirectional antennas. Short pulses of microwave power carry the intelligence of the messages utilizing "pulse position modulation" to modulate the pulses and "time division" to multiplex the channels. The eight-message circuits which each system provides are high grade telephone circuits and can be used for signaling, dialing, facsimile, picture transmission, or multichannel voice frequency telegraph. Two-way voice transmission over radio links totaling 1,600 miles and one way over 3,200 miles have been accomplished successfully in demonstrations.

Electric Machinery

46-202—Asynchronous and Single-Phase Operation of Synchronous Machines; *A. W. Rankin* (*M '45*). *30 cents.* The object of this paper is to present an analysis of the asynchronous and single-phase operation of synchronous machines. The analysis of such operation is quite involved, and the number of pertinent variables is so large that the physical aspects of the problem tend to become completely submerged in the mathematical manipulations involved. In the subject paper the analysis is made by means of equivalent circuits, and the various torques and currents of the synchronous machines are all presented in terms of the currents and voltages of these equivalent circuits. To illustrate the practicability of the methods, a numerical example is given comparing the asynchronous and single-phase operating characteristics of synchronous machines with complete and incomplete end rings on the damper windings. This example presents the torque curves, the stator and rotor currents, and the current distribution in the leading and trailing bars of the damper winding.

Electronics

46-203—Frequency Performance of Thyratons; *H. H. Wittenberg* (*A '46*). *20 cents.* The frequency performance of small thyratrons is investigated by supplying anode voltage from a variable-frequency electronic generator of 1,400-watts output capacity. At high audio frequencies there is a departure from the 60-cycle-per-second performance; the grid control characteristic resolves itself into two characteristics: a starting characteristic and an extinguishing characteristic. The starting characteristic is shown to be a function of grid–anode capacitance and grid resistance. The extinguishing characteristic is determined by deionization effects and so is a function of frequency, grid resistance, anode current, tube geometry, and gas pressure.

46-204-ACO—Analysis of Four-Terminal Networks Containing Vacuum Tubes; *W. R. Abbott* (*A '40*). *15 cents.* A method is given for handling as a class four-terminal networks containing vacuum tubes. In linear passive four-terminal networks, three independent functions of frequency are sufficient to describe the behavior of the network at its input and output terminals. If the network contains class *A* operated vacuum tubes, the network remains linear; but four independent functions of frequency are necessary to describe its behavior. In this paper three sets of four independent functions are discussed, and an example is worked out in which all three are used.

PERSONAL • • • •

Robert Hamilton Barclay (A '14, M '18, F '28) chief electrical engineer, electrical engineering department, J. G. White Engineering Corporation, New York, N. Y., has been appointed 1946–47 chairman of the AIEE board of examiners of which he has been a member since 1943. Born in St. Louis, Mo., August 10, 1887, Mr. Barclay attended Washington University. After holding various positions with the Laclede Power Company of St. Louis (Mo.), the Hartford (Conn.) Electric Light and Power Company, and at the World's Fair in St. Louis in 1904, he became associated with the Bell Telephone Company of Missouri, St. Louis, and the Missouri and Kansas Telephone Company, Kansas City, Mo., in 1908 as telephone engineer and superintendent of buildings and power plants as well as chief draftsman. In 1912 he entered the employ of the Kansas City (Mo.) Terminal Railway Company as assistant electrical engineer, and in 1915 he joined the Brooklyn–Manhattan Transit Corporation, Brooklyn, N. Y., in the same capacity. From 1917 to 1922 Mr. Barclay was employed as chief electrical engineer for The Foundation Company, New York, N. Y. While thus employed he was responsible for the electrical engineering and electrical construction of two large loading plants for the United States Government during World War I and also for the design and construction of several shipyards and approximately 40 vessels. Mr. Barclay became chief electrical engineer for Starrett and Van Vleck, Architects, New York, N. Y., in 1922, and in 1924 was appointed electrical engineer for the Stone and Webster Corporation, Boston, Mass. After three years as president of McClelland Barclay Art Products, Inc., New York, N. Y., he was appointed chief of the analysis and reports division, Federal Power Commission, National Power Survey, Washington, D. C., in 1934. He became regional director of the Commission in New York in 1936 with jurisdiction over the area embracing New England, New York, New Jersey, Pennsylvania, Delaware, Maryland, and the District of Columbia. In 1938 he was expert adviser to the Joint Committee on the Investigation of the Tennessee Valley Authority on matters relating to the design, construction, operation, and integration of the power generating facilities of the Tennessee Valley Authority. He joined the J. G. White Engineering Corporation in 1941. Mr. Barclay became a member of the Engineering Societies Library board in 1942 and and has been vice-chairman since 1944. Mr. Barclay is a member of the Radio Club of America, the Society of American Military Engineers, and The Engineers' Club of New York.

M. S. Oldacre (A '13, M '42) director of research, Utilities Research Commission, Commonwealth Edison Company, Chicago, Ill., has been appointed 1946–47 chairman of the AIEE committee on electric machinery of which he has been a member since 1939. He was born January 8, 1889, in Chicago, Ill., and was graduated in 1910 from Purdue University with a bachelor of science degree in electrical engineering. Following his graduation he was employed by the Commonwealth Edison Company as electrical mechanic and helper in the construction department and in 1912 was made testing engineer. He remained with the Commonwealth Edison Company until in 1918 he joined the United States Army to serve as second lieutenant during the first World War. In 1919 Mr. Oldacre entered the employ of the Westinghouse Electric and Manufacturing Corporation, South Philadelphia, Pa., as engineer in the stoker engineering department, and in 1920 he became stoker service engineer in charge of stoker service work in the Chicago, Ill., area. He was transferred to Minneapolis, Minn., in 1922 as sales engineer for the Westinghouse company and in 1923 returned to Chicago as engineer specialist on turbines, capacitors, and stokers. In 1926 he re-entered the employ of the Commonwealth Edison Company as engineer in the engineering department. He was advanced to the position of research engineer in 1935 and was made equipment and research engineer in 1937. In 1946 he was appointed to the re-

M. S. Oldacre

S. M. Dean

R. H. Barclay

J. G. Tarboux

C. W. Evans

M. J. Steinberg

H. W. Collins

search commission. Mr. Oldacre's Institute activities include past membership on the Standards and transfers committees.

Samuel Mills Dean (A '25, M '41, F '46) chief engineer of the system, Detroit (Mich.) Edison Company, has been appointed chairman of the AIEE committee on the Edison Medal for 1946–47. Born in Traverse City, Mich., July 15, 1891, he was graduated from Michigan State College in 1914 with a bachelor of science degree in electrical engineering. From 1914 until 1916 he was with the Michigan Miller's Mutual Fire Insurance Company, Lansing, after which he entered the test course of the General Electric Company, Schenectady, N. Y. He was transferred to the general office of the commercial department in 1918 and in 1919 became sales engineer in the Chicago, Ill., district office. In 1921 he was made assistant manager of the company's Detroit office. Joining the Detroit Edison Company in 1925, he held various engineering positions before his appointment as senior engineer in charge of the engineering division of the company in 1927. Mr. Dean became chief assistant superintendent of the electric system in 1930 and chief engineer of the system in 1943. In the latter position he has charge of all system engineering and of planning system design. He was 1940–41 secretary of the AIEE Detroit Section. He is a member of Tau Beta Pi and the Engineering Society of Detroit and has contributed a number of articles to technical publications.

Joseph Galluchat Tarboux (A '21, M '32, F '43) professor of electrical engineering, Cornell University, Ithaca, N. Y., has been appointed chairman of the AIEE committee on education for 1946–47. Professor Tarboux was born in Juiz de Fora, Minas Geraes, Brazil, August 15, 1898. He was graduated from Clemson Agricultural College in 1918 with bachelor of science degrees in electrical engineering and mechanical engineering, and from Cornell University he received the degrees of electrical engineer in 1922, master of electrical engineering in 1925, and doctor of philosophy in 1936. From 1919 to 1929 Professor Tarboux was instructor and assistant professor of electrical engineering, Cornell University. He joined the faculty of the University of Tennessee, Knoxville, in 1929, as professor in charge of the electrical engineering department, and held that position until his recent return (*EE, Aug-Sept '46, p 417*) to the faculty of Cornell University. Professor Tarboux is a member of the Knoxville Technical Society and the Knoxville Science Society, and has been an AIEE Student Branch counsellor since 1930. He is a member of Eta Kappa Nu, Tau Beta Pi, Phi Kappa Phi, and Sigma Xi, and is the author of several books.

Harold Wilson Collins (A '22, M '42) superintendent of the electrical system, The Detroit (Mich.) Edison Company, has been appointed 1946–47 chairman of the AIEE committee on protective devices of which he has been a member since 1931. Born December 23, 1895, in Owosso, Mich., Mr. Collins is a graduate of the University of Michigan, Ann Arbor, with a degree in electrical engineering (1918). After several months as an instructor in the University of Michigan's electrical engineering department, he began work for The Detroit Edison Company in 1919 in the operating department. His first duties were concerned with the testing of electric apparatus and underground cables. In 1926 he was appointed relay engineer in charge of system protection, and in 1928 he assumed additional responsibilities for the performance of other classes of equipment in order to maintain service continuity and standards. Mr. Collins became assistant to the superintendent of the electrical system in 1929 and project engineer in 1930. He was made superintendent of the electrical system in 1945.

Max Jacob Steinberg (A '24, M '32) division engineer, system engineering department, Consolidated Edison Company of New York (N. Y.), Inc., has been appointed 1946–47 chairman of the AIEE committee on power generation of which he has been a member since 1939. He was born in Russia, April 15, 1900, and received the bachelor of science degree in 1922 and the master of science degree in 1923 from Massachusetts Institute of Technology. He received the degree of bachelor of laws in 1928 from Brooklyn Law School. In 1920 and 1921 Mr. Steinberg was associated with the General Electric Company, West Lynn, Mass., and in 1923 he entered the employ of the Brooklyn (N. Y.) Edison Company to supervise the testing of generating equipment. He became engaged in general engineering in connection with system operating in 1929. Mr. Steinberg was appointed division engineer for the Consolidated Edison Company in 1937. He is a part-time lecturer at New York University and Brooklyn Polytechnic Institute. Mr. Steinberg, who is also a member of the American Society of Mechanical Engineers, is at present chairman of the joint AIEE–ASME Committee on a Recommended Specification for Prime-Mover Speed Governing. He is a member of the New York State Society of Professional Engineers.

Carl Wimmer Evans (A '36, M '40) editor, *Electrical South*, W. R. C. Smith Publishing Company, Atlanta, Ga., has been appointed 1946–47 chairman of the AIEE committee on domestic and commercial applications of which he has been a member since 1943. Mr. Evans was born November 23, 1905, in San Antonio, Tex. After attending the University of Texas, he became journeyman electrician for the San Antonio Public Service Company in 1928 and was named underground distribution engineer in 1929. In the latter position he had charge of the planning and design of the company's underground distribution system. In 1931 Mr. Evans was appointed industrial power sales engineer, and in 1933 commercial engineer in charge of the rate and statistical division. He resigned from this position in 1936 to join the staff of *Electrical South* as associate editor, becoming editor later that year. Mr. Evans served as secretary of the AIEE Georgia Section for 1941–44 and as chairman for 1945–46. He is a member of the Illuminating Engineering Society, the International Association of Electrical Inspectors, and the Georgia Engineering Society.

Titus George LeClair (A '24, M '29, F '40) staff engineer, Commonwealth Edi-

son Company, Chicago, Ill., has been appointed chairman of the AIEE committee on registration of engineers for 1946–47. Except for one year with the General Electric Company, Schenectady, N. Y., his entire professional career has been with the Commonwealth Edison Company which he served variously as cable engineer, substa-

T. G. LeClair

tion field engineer, engineer of system protection, and development engineer, before his recent appointment as staff engineer. Mr. LeClair has served on many committees and has been generally active in Institute affairs. He is AIEE vice-president for the Great Lakes District for 1946–47. For further biographical details see *Electrical Engineering*, March 1946, page 132.

Thomas R. Rhea (A '41) engineer, chemical section, industrial engineering department, General Electric Company, Schenectady, N. Y., has been appointed 1946–47 chairman of the AIEE committee on electrochemistry and electrometallurgy of which he has been a member since 1942. Born on May 2, 1900, in Bonham, Tex.,

T. R. Rhea

Mr. Rhea received a bachelor of science degree from the Massachusetts Institute of Technology and a master of science degree from Union University. He entered the employ of the General Electric Company in 1924 as application and design engineer. He is a member of the Association of Iron and Steel Engineers.

H. K. Polk (A '45) formerly assistant superintendent of maintenance for the Western United Gas and Electric Company, Aurora, Ill., and **R. M. Wainwright** (A '37) formerly research engineer for the Montana–Dakota Utilities Company, Loma, Mont., have been named assistant professors of electrical engineering at the University of Illinois, Urbana. Professor Polk had been with the Western United company since 1936. During the war he taught the fundamentals of electrical engineering, a-c circuits, and power transmission and distribution in the War Training Program carried on for war workers under supervision of the university. Professor Wainwright spent three years during the war in Washington, D. C., with the War Department, where he directed the writing of books on fundamentals of radar and later was technical consultant with the Signal Corps on analysis of enemy equipment. Before joining the staff of Montana–Dakota Utilities in 1938, he had been associated with the Montana Power Company, Butte.

W. O. Kurtz (A '17, F '40) vice-president, Illinois Bell Telephone Company, Chicago, has retired. Mr. Kurtz was born in Minnesota in 1884 and was graduated from Cornell University in 1905. Immediately after his graduation Mr. Kurtz entered the employ of the New York Telephone Company and, before becoming chief engineer of the Illinois company in 1924, was associated with the Eastern group of Bell Telephone companies, the Bell Telephone Company of Pennsylvania, and the American Telephone and Telegraph Company. He was made general manager of the state area of the Illinois company in 1928 and of the Chicago area in 1930. In 1938 he was appointed vice-president. He is a member of the Western Society of Engineers.

P. M. Honnell (M '46) formerly colonel and member of the faculty of the department of chemistry and electricity of the United States Military Academy, West Point, N. Y., has joined the staff of the University of Illinois, Urbana. At West Point Colonel Honnell was in charge of the department laboratories and was director of the electronics course. He entered military service in 1941 as a member of the faculty of the Signal Corps School in Fort Monmouth, N. J. Colonel Honnell received the Legion of Merit for his work at the Military Academy. He holds the degrees of bachelor of science and electrical engineer from the Agricultural and Mechanical College of Texas, and the degree of master of science from Massachusetts Institute of Technology and from California Institute of Technology. He completed additional graduate work in Vienna, Austria, and Paris, France.

A. W. Clement (A '25, M '34) formerly lieutenant colonel, Army of the United States, has returned to Bell Telephone Laboratories, Inc., New York, N. Y. Colonel Clement had been with the laboratories from 1925 until he entered upon active duty as a captain in 1940. During his military service he conducted demonstrations of advanced types of radar and electronic fire control equipment in Hawaii and made a study of seacoast artillery matériel and operations in the western Pacific. In 1946 Colonel Clement was awarded the Legion of Merit for his wartime services.

G. R. Anderson (A '22, M '29) formerly director and chief engineer of the electrical division of Fairbanks, Morse, and Company, Beloit, Wis., has been appointed director of engineering of the company's Beloit works. Mr. Anderson has been associated with Fairbanks, Morse, and Company since 1922. **G. H. Herrick** (A '26, M '33) succeeds Mr. Anderson as chief engineer of the electrical division. Mr. Herrick, formerly section design engineer on synchronous machinery, has been with the company since 1928.

R. R. Newquist (A '40) formerly manager, Washington, D. C., district office, Allis-Chalmers Manufacturing Company, has been elected vice-president in charge of sales of Roots-Connersville Blower Corporation, Connersville, Ind. Prior to his affiliation with the Allis-Chalmers company, Mr. Newquist had been with the Reliance Electric and Engineering Company, Cleveland, Ohio, from 1929 to 1932 and the Louis Allis Company, Milwaukee, Wis., from 1932 to 1934.

T. C. Stephens (A '44) formerly instructor in electrical engineering, University of Iowa, Iowa City, and **A. H. Wulfsberg** (A '43) of Cedar Rapids, Iowa, have joined the research division of the Collins Radio Company, Cedar Rapids. A graduate of the State University of Iowa, Mr. Stephens was associated with the development of the proximity fuse. Mr. Wulfsberg, a graduate of the University of Minnesota, was employed by Sylvania Electric Products, Inc., during the war.

A. F. Darland (A '20, M '29) superintendent of the light division, Public Utilities Department, City of Tacoma (Wash.), since 1945, has returned to the United States Bureau of Reclamation's Columbia Basin Project headquarters, Coulee Dam, Wash., in an administrative position. Previous to his former affiliation with the Columbia Basin Project, 1934–45, Mr. Darland had been associated with the Public Utilities Department of the City of Tacoma from 1923 to 1934.

R. C. Graham (A '41) formerly assistant to the director of research, General Cable Corporation, Bayonne, N. J., has joined the staff of the Rome (N. Y.) Cable Corporation, as chief product engineer. Mr. Graham had been connected with the General Cable Corporation since 1930. During the war he served on government committees responsible for the development of telephone, radio, and radar cables.

W. E. Wickenden (A '07, F '39) president, Case School of Applied Science, Cleveland, Ohio, and junior past president of AIEE, has announced his intention of retiring August 31, 1947. Doctor Wickenden has been president of the Case School since 1929 and during his presidency more than half of its graduates have received their degrees. He has been responsible for the development of an evening division, a graduate school, and an organized program of research at the Case School. Widely known for his civic activities, Doctor Wickenden has been at various times a director of the Cleveland Chamber of Commerce, chairman of the Ohio Highway Planning Board, and a member of the Postwar Planning Council of Greater Cleveland, and of the distribution committee of the Cleveland Foundation. He is a director of the Apex Electrical and Manufacturing Company, of the Equity Savings and Loan Company, a trustee of the Cleveland Clinic Foundation, and a member of the board of trustees of Case and Lake Erie College. A fuller biography of Doctor Wickenden appears in the March 1945 issue of *Electrical Engineering*, pages 122–3.

W. A. Upham (A '29, M '42) formerly general superintendent of distribution, United Illuminating Company of New Haven and Bridgeport, Conn., has been appointed chief engineer in charge of engineering. Mr. Upham joined the company in 1927 as an electrical engineer and was appointed superintendent of distribution for the Bridgeport division in 1927. In 1940 he became general superintendent for both the New Haven and Bridgeport divisions.

O. C. Brill (A '08, M '20) engineer in charge of plant engineering administration, American Telephone and Telegraph Company, New York, N. Y., has retired. Mr. Brill entered the Bell System in 1910 as an employee of the Pacific Telephone and Telegraph Company. After serving as a major in the Signal Corps in World War I, he entered the operations and engineering department of the American Telephone and Telegraph Company. He since has had various plant maintenance, installation, and engineering assignments. Mr. Brill plans to live in Los Altos, Calif.

C. M. Lynge (M '22) formerly assistant works manager, General Electric Company, Bridgeport, Conn., has been appointed manager of manufacturing for the company's appliance and merchandise department. Mr. Lynge joined the General Electric Company after his graduation from Yale University in 1912. At first Mr. Lynge was assigned to Schenectady, N. Y., and later to Pittsfield, Mass. He was transferred to Bridgeport in 1920 as manufacturing engineer. In 1929 he was made assistant works manager and in 1945 was given the additional title of assistant manager of manufacturing for the appliance and merchandise department.

R. E. Mathes (A '37) formerly lieutenant in the United States Naval Reserve, Bureau of Ships, Washington, D. C., recently was released from active duty, and has joined Finch Telecommunications, Inc., Clifton, N. J., as chief engineering and plant manager. With the RCA Laboratories, New York, N. Y., since his graduation from the University of Minnesota in 1924, Mr. Mathes had worked on the development of facsimile equipment.

Samuel Seely (A '38, M '44) formerly member of the staff of the radiation laboratory, Massachusetts Institute of Technology, Cambridge, has been appointed associate professor of electronics at the postgraduate school of the United States Naval Academy, Annapolis, Md. Doctor Seely, a member of the staff of the department of electrical engineering of the College of the City of New York, N. Y., has been on leave of absence since 1941.

L. D. Martin (A '40, M '43) senior electrical engineer, United States Engineers, Atlanta, Ga., has been awarded the Army Service Forces Commendation for Meritorious Civilian Service. The citation was made in recognition of his "loyalty, initiative, and exemplary performance of duty . . . . from October 1942 to June 1946."

J. W. Weigt (A '19, M '26) formerly head of the railway, industrial truck and locomotive department, Electric Storage Battery Company, New York, N. Y., has been appointed manager of the New York branch of that company. Mr. Weigt entered the company's employ in 1920 as a salesman in the New York branch.

E. G. Martin (A '41) formerly staff member and engineering consultant with the radiation laboratory, Massachusetts Institute of Technology, and with the radio research laboratory, Harvard University, Cambridge, has become a partner and president of the Martin-Hubbard Corporation, engineering consultants, Boston, Mass.

D. T. Braymer (A '42) formerly western editor, *Electrical World*, Chicago, Ill., has been transferred to New York, N. Y., as managing editor. A 1933 graduate of Cornell University, Mr. Braymer joined the staff of *Electrical World* as editorial assistant in 1935, was made assistant editor in 1936, and western editor in 1939.

H. L. Brouse (A '32, M '35) development engineer, Crosley Corporation, Cincinnati, Ohio, and **E. J. Bussard** (A '25) chief radio development engineer, Crosley Radio Corporation, Cincinnati, Ohio, have received citations from the United States Navy for their contributions to the development of the variable-time proximity fuse.

H. H. Hausner (M '40) formerly chief research engineer, General Ceramics and Steatite Corporation, Keasbey, N. J., has established himself as a consulting engineer, in New York, N. Y. Doctor Hausner recently was appointed research associate with New York University, New York, and research consultant with the Ceramic Institute, Rutgers University, New Brunswick, N. J.

F. K. McCune (A '33, M '43) formerly assistant executive manager, General Electric Company, Lynn, Mass., has been appointed a member of the company's apparatus design engineering staff at Schenectady, N. Y. Mr. McCune entered the employ of the General Electric Company immediately after his graduation from the University of California in 1928.

Tomlinson Fort (A '27, M '35) manager, central station department, and **R. J. Weber** (M '45) manager of the central station and transformer division, Westinghouse Electric Corporation, East Pittsburgh, Pa., have been awarded the Westinghouse Order of Merit.

A. H. Chandler (A '44) engineer in the industrial engineering department, Consolidated Gas, Electric Light, and Power Company, Baltimore, Md., recently received a certificate of appreciation from the Third Service Command in recognition of his part in the Utilities Wartime Aid Program.

Lionel Swift (A '45) formerly engineer in charge of technical services, Quebec Power Company, Quebec, Canada, has been made assistant superintendent of the power division of the company. A graduate of McGill University, Mr. Swift joined the company in 1945.

F. C. Stockwell (A '12, M '27) professor and chairman of the department of electrical engineering, Stevens Institute of Technology, Hoboken, N. J., recently received the honorary degree of doctor of engineering from that institute.

Haraden Pratt (A '15, F '37) vice-president and chief engineer, American Cable and Radio Corporation, New York, N. Y., has been elected chairman of the Radio Technical Planning Board for one year beginning October 1, 1946. Mr. Pratt was among the communications industry representatives at the Bikini atomic bomb tests.

C. E. Clutts (A '31) formerly lieutenant commander, United States Naval Reserve, has returned to Bell Telephone Laboratories, Inc., New York, N. Y. Mr. Clutts was assigned to the electronic division of the Bureau of Ships, Washington, D. C.

Philo Holcomb (A '40, M '41) formerly general inspector, Western Union Telegraph Company, New York, N. Y., has been appointed traffic engineer of international communications. Mr. Holcomb is the inventer of the Varioplex communications system.

G. R. Henninger (A '22, F '43) AIEE editor, New York, N. Y., who during the war was colonel and chief of the maintenance data section, maintenance division of the Air Matériel Command, Wright Field, Dayton, Ohio, has received a certificate of meritorious service from the Army Air Forces. "His meritorious service," the certificate states, "has contributed to the successful accomplishment of the mission of the Army Air Forces in World War II."

W. J. Kozuchowski (A '41) formerly production engineer, radio district, Philadelphia (Pa.) Signal Corps Procurement District, is now chief engineer of the Electrical Transformer Company. Mr. Kozuchowski holds the degrees of bachelor of electrical engineering and bachelor of mechanical engineering from the College of the City of New York.

L. F. Munzer (A '31, M '46) formerly major in the United States Army Air Corps, has joined the staff of RCA Communications, Inc., Marion, Mass., as assistant engineer. Mr. Munzer, who was graduated from the College of the City of New York in 1926, previously had been employed by the RCA company at Turkerton, N. J.

Herbert Sherman (A '41) recently released from the United States Navy as a lieutenant, has rejoined the Signal Corps as a senior engineer attached to the Philadelphia Signal Corps Procurement District. He received the degree of bachelor of electrical engineering from the College of the City of New York in 1940.

Stephen Chaika (A '45) formerly lieutenant, United States Naval Reserve, has been made assistant project engineer with the Sperry Gyroscope Company, Mineola, N. Y. He is a 1943 graduate of the College of the City of New York.

R. M. Cunningham (A '40) of the operations and engineering department, American Telephone and Telegraph Company, New York, N. Y., has been placed in charge of the group handling depreciation practices in the operating results division.

Thurman Oakley (A '45) formerly meter superintendent, Illinois Power Company, Belleville, has been appointed superintendent of the Madisonville, Ky., light and power plant.

V. P. Hessler (A '20, F '43) professor and head of the electrical engineering department, University of Kansas, Lawrence, has become a consultant to the Naval Research Laboratory.

C. L. Sampson (A '35, M '39) general manager, Northwestern Bell Telephone Company, Des Moines, Iowa, also has been elected vice-president of the company.

O. W. Tuthill (M '45) formerly studies engineer, New Jersey Bell Telephone Company, Newark, has been appointed engineer of exchange plant extension.

OBITUARY ● ● ● ●

Frank Whitney Smith (A '05, M '12) retired president of the Consolidated Edison Company of New York (N. Y.), Inc., died July 22, 1946. Born in Alden, N. Y., June 16, 1867, Mr. Smith traced his ancestry to Sir Francis Drake, Elizabethan admiral and explorer. Another ancestor fought with the Continental Army. Mr. Smith commenced his utility career as office boy for the United States Illuminating Company, New York, in 1880, three months after Edison's invention of the incandescent lamp. Three years later he became general clerk and in 1889 general paymaster of the company's successor, the United Electric Light and Power Company. Thereafter he served as assistant auditor, assistant secretary, and secretary of the company. He was elected a director in 1902 and secretary of the Brush Electric Illuminating Company in 1905. He was named vice-president in 1912 and general manager in 1916. He was elected chairman of the board of directors of the New York and Queens Electric Light and Power Company in 1926 and in 1929 president of the Brush Electric Illuminating Company. In 1931 he became vice-president of the New York Edison Company and in 1932 president. He continued in that position after the Consolidated Edison Company of New York was incorporated until he retired in 1937. He was at one time president of the Brooklyn Edison Company. For many years he was a director of the Brooklyn Edison Company, the Westchester Lighting Company, the Yonkers Electric Light and Power Company, the Consolidated Telegraph and Electrical Subways Companies, and the New York Steam and Tarrytown Terminal Corporations. He held various offices in the now defunct National Electric Light Association. He was president of the Electric Vehicle Association of America in 1923. With H. C. Cushing, Jr., he was author of "The Electric Vehicle Handbook." He was a member of the Electrical Association of New York, the New York Electrical Society, and the Engineers' Club of New York. He was a trustee of the Northwestern Mutual Life Insurance Company and the Waldorf Astoria Corporation.

Alexander Russell Stevenson, Jr. (A '20, F '37) staff assistant to the vice-president in charge of engineering, General Electric Company, Schenectady, N. Y., died August 28, 1946. Doctor Stevenson, who was born May 28, 1893, in Schenectady, N. Y., received the degree of civil engineer from Princeton University in 1914. He received from Union College the degree of master of science in electrical engineering in 1915 and the degree of doctor of philosophy in 1917. He entered the United States Air Service in 1917 and was first officer in charge of testing at Langley Field, Va. He went to France later that year as officer in charge of the radio and electrical section of the Air Service and in 1918 was made officer in charge of flying and testing. He entered the power and mining engineering department of the General Electric Company in 1919 and was placed in charge of application engineering on synchronous motors and generators. In 1923 he was appointed to the staff of the vice-president in charge of engineering. Doctor Stevenson was responsible for the studies which led to the entrance of the company into household refrigeration manufacturing. He assisted Doctor Robert E. Doherty (F '39) in starting an advanced course in engineering and since 1930 had directed the program for the company. He was secretary of the company's engineering council and assisted the company's six operating departments and the laboratories with their educational and training programs. Doctor Stevenson was a fellow of the American Society of Mechanical Engineers, a past president of the American Society of Refrigeration Engineers, and a past president of the Private Flyers Club. He was a member of the Society for the Promotion of Engineering Education, the first Jet-Propulsion Subcommittee of the National Advisory Committee for Aeronautics, and the Civilian Advisory Council of the Military Training Division, Army Ordnance Department.

Albert Sears Crane (A '04, M '13) retired hydraulic engineer, and former vice-president of the J. G. White Engineering Corporation, New York, N. Y., died August 26, 1946. Mr. Crane was born May 30, 1868, in Addison, N. Y., and was graduated from Cornell University with the degree of civil engineer in 1891. He was appointed assistant to the city engineer of Newton, Mass., after graduation and in 1895 became assistant engineer in the department of City Works, Brooklyn, N. Y. He subsequently held the positions of chief assistant engineer of the Michigan, Lake Superior Power Company plant, Sault Sainte Marie, in 1898; chief engineer, Lake Superior Power Company, Sault Sainte Marie, in 1901; and principal assistant engineer of the Sanitary District of Chicago, Ill., in 1902. He joined the J. G. White company as chief hydraulic engineer in 1905 and was named vice-president in 1913. He remained in that position until in 1928 he became a consulting hydraulic engineer. During his long career, Mr. Crane engaged in the construction of 30 large earth dams, 60 masonry dams, 40 hydroelectric stations, and 6 irrigation projects. He was a member of the American Society of Civil Engineers, the Western Society of Engineers and of the Cornell, New York Lawyers, and Brooklyn Engineers Clubs.

Stanley Compton Wilcox (A '38, M '41) retired electrical engineer, Cleveland, Ohio, died June 22, 1946. Mr. Wilcox was born March 10, 1890, in Cleveland and studied at the Case School of Applied Science. He commenced his career as district engineer for the Western Union Telegraph Company from 1913 to 1916. He was afterwards

facility engineer with the Ohio Bell Telephone Company, Cleveland, until 1919. As an instructor in electricity from 1920 to 1924, he served the Cleveland Board of Education. He joined the Durkee Electric Company as electrical engineer in 1929 and was chief electrical engineer for the Great Lakes Exposition from 1936 to 1938. In 1938 he became electrical engineer for Cuyahoga County, Cleveland. As such he designed and installed the light system for the city's Main Avenue Bridge Project which was pronounced the finest installation of viaduct lighting in America by the committee on street lighting of the Illuminating Engineering Society.

Harold Platt Daniels (A '02) retired electrical engineer of Clinton, N. Y., died July 1, 1946. Mr. Daniels, who was born in New York, N. Y., February 3, 1881, was graduated from Columbia University in 1902. He was employed in the electrical testing department of the General Electric Company, Schenectady, N. Y., and in 1903 was made head of turbine testing. In 1904 he was transferred to the lighting engineering department. From 1905 until his retirement he was associated with Peet and Powers, Inc., New York, for which he was secretary and director. In World War I Mr. Daniels supervised electrical work in the United States Bag Loading Plant, Seven Oaks, Va., and during the last war at the Quonset Point (R. I.) Naval Base.

MEMBERSHIP...

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before October 21, 1946, or December 21, 1946, if the applicant resides outside of the United States or Canada.

To Grade of Fellow

Wheeler, H. A., 259-09 Northern Blvd., Great Neck, N. Y.

1 to grade of Fellow

To Grade of Member

Bonner, J. A., General Elec. Co. Ltd., Witton, Birmingham, England.
Burzlander, W. A., Rocky Mt. Eng. Co., Denver, Colo.
Butcher, W., General Elec. Co., Glasgow, Scotland.
Carpenter, N. G., Gulf States Utilities Co., Lake Charles, La.
Catlin, J. R., British Admiralty, Bath, Somerset, England.
de Leva, M. M., 29 Via Pastrengo, Turin, Italy.
Dorris, R. C., Westinghouse Elec. Corp., Bloomfield, N. J.
Dunbar, E., Potomac Elec. Pr. Co., Washington, D. C.
Edelman, J. E., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Esher, F. N., Sperry Gyroscope Co., Inc., Great Neck, N. Y.
Gunn, G. J. T., R. A. Hanright, Toronto, Ontario, Canada.
Gupta, N. R., Public Health Engg. Dept., U. P. Lucknow, India.
Hahn, P. T., General Armature & Mfg. Co., Lock Haven, Pa.
Hill, W. W., Alabama Polytechnic Inst., Auburn, Ala.
Jones, A. A., Anaconda Wire & Cable Co., Hastings-on-Hudson 6, N. Y.
Lawton, C. S., Western Union Tel. Co., New York, N. Y.
Mac Gregor, R. M., Westinghouse Elec. Corp., East Pittsburgh, Pa.
McMann, I. H. S., Riverside and Dan River Cotton Mills, Danville, Va.
Murray, R. R., American Embassy, Teheran, Iran.
Payne, B. T., Nepsco Services, Inc., Augusta, Maine.
Rife, C. J., Bell Aircraft Corp., Buffalo, N. Y.
Schroedel, H. E., John Graham Architects & Engrs., Seattle, Wash.
Shore, H., Federal Machine & Welder Co., Warren, Ohio.
Smith, H., Davis Transformer Co., Concord, N. H.
Taylor, P. R., St. Regis Paper Co., East Pepperell, Mass.
Weller, G. W., Empire Steel Corp., Mansfield, Ohio.
Wilkes, F. M., Southwestern Gas & Elec. Co., Shreveport, La.
Woolgar, E. J., F/O—R.A.F.O., Air Ministry, South Cerney, Gloucestershire, England.

28 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

Boggis, M. C., General Elec. Co., Schenectady, N. Y.
Brailey, M. L., General Elec. Co., Pittsfield, Mass.
Dickinson, T. M., General Elec. Co., Schenectady, N. Y.
Exnicios, R. B., General Elec. Co., Schenectady, N. Y.
Gundersen, N. A., Parker Bateman & Chase, Clinton, Mass.
Harrington, J. D., USN, Worcester, Mass.
Heiser, W. H., General Elec. Co., Pittsfield, Mass.
Hirst, J. M., Thayer School of Engg., Dartmouth College, Hanover, N. H.
Lazarek, C. J., Narra Elec. Co., Westerly, R. I.
Nisula, A. C., Hixon Elec. Co., Boston, Mass.
Parker, J. H., University of Maine, Orono, Maine.
Thalheimer, J. C., Jr., New England Tel. & Tel. Co., Boston, Mass.
Walter, W. E., General Elec. Co., Pittsfield, Mass.

2. Middle Eastern

Balentine, W. H., Edison-Splitdorf Corp., Bethlehem, Pa.
Balsam, L. L., General Elec. Co., Erie, Pa.
Barse, G. R., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Berlin, B. A., Heinemann Elec. Co., Trenton, N. J.
Bradstock, R. B., General Elec. Co., Erie, Pa.
Cole, J. R., Navy Dept., Bureau of Ships, Washington, D. C.
Dunkelman, L., Bureau of Ships, Navy Dept., Washington, D. C.
Farber, W. R., Westinghouse Elec. Corp., Sharon, Pa.
Garrahan, C. J. (re-election), Swarthmore College, Swarthmore, Pa.
Goldsmith, H. M., Philadelphia Elec. Co., Philadelphia, Pa.
Huntsman, O. A., General Elec. Co., Philadelphia, Pa.
Irby, J. G., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Lamb, J. H., Jr., E. I duPont de Nemours & Co., Wilmington, Del.
Manhart, R. A., RCA Victor Div., RCA, Camden, N. J.
Michel, R. W., National Cash Register Co., Dayton, Ohio.
Pickering, L. J., Koppers Co., Pittsburgh, Pa.
Reid, J. G., Jr., Nat'l. Bureau of Standards, Washington, D. C.
Rigie, B., National Advisory Comm. for Aeronautics, Cleveland, Ohio.
Sabol, J. T., Ohio Crankshaft Co., Cleveland, Ohio.
Schneider, J. L., North Elec. Mfg. Co., Galion, Ohio.
Scull, H. M., Capt., USN, Inspector of Naval Material, Cincinnati, Ohio.
Steen, C. R., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Theiss, J. S., National Cash Register Co., Dayton, Ohio.
Woodhull, J. H., Naval Ordnance Lab., Washington, D. C.

3. New York City

Cervino, C. A., International Business Machines Corp. New York, N. Y.
Israel, L. J., Westinghouse Elec. Corp., New York, N. Y.
James, E. W., Norden Laboratories Corp., New York, N. Y.
Kleckner, U. F., Norden Laboratories, New York, N. Y.
Kult, M. L., Lieut., SC, USAAF, c/o PM, New York.
Norde, L., Press Wireless Mfg. Co., Long Island City, N. Y.
Price, E. J., Consolidated Edison Co. of N. Y., Inc., New York, N. Y.
Simpson, S. A., Simpson Elec. Corp., New York, N. Y.
Sukaskas, J. A. (re-election), W. L. Maxson Corp., New York, N. Y.
Wallace, E. C., Specialties, Inc., Syosset, N. Y.

4. Southern

Buck, T. A., General Elec. Co., Atlanta, Ga.
Carver, M. L., Gulf States Utilities Co., Lake Charles, La.
Duchesne, J. G., Jr., Sperry Gyroscope Co., Inc., Savannah, Ga.
Early, J. R., The Okonite Co., Roanoke, Va.
Elrod, J. L., General Elec. Co., Raleigh, N. C.
McDonald, C. H., Southwestern Gas & Elec. Co., Shreveport, La.
Nolan, W. R., Southwestern Gas & Elec. Co., Shreveport, La.
Vandling, J. R., Carbide-Carbon Chemicals Co., Oak Ridge, Tenn.

5. Great Lakes

Baldasar, T. L., Westinghouse Elec. Corp., Chicago, Ill.
Bollero, J. P., Carnegie-Illinois Steel Corp., Chicago, Ill.
Brown, A., Jr., The Austin Co., Chicago, Ill.
Buerschinger, D. R., 714 Hubbard St., Green Bay, Wis.
Crooks, J. C., General Motors Corp., La Grange, Ill.
Dahl, A. W., Minnesota Pr. & Lt. Co., Duluth, Minn.
Freund, R. J., Swift & Co., Chicago, Ill.
Greene, R. H., The Austin Company, Chicago, Ill.
Klein, C. J., Bendix Aviation Corp., South Bend, Ind.
Levin, E. J., Western Elec. Co., Chicago, Ill.
Morrow, G. L., 5046 S. Greenwood, Chicago, Ill.
Nelson, I. W., Route 1, Box 1, Evansville, Minn.
Noeske, O. W., Allis-Chalmers Mfg. Co., West Allis, Wis.
Smilanic, N. A., Electro-Motive Div. of G.M.C., La Grange, Ill.
Stone, N. T., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

7. South West

Cupples, J. J., Westinghouse Elec. Corp., St. Louis, Mo.
Johnson, B. G., Houston Lighting & Pr. Co., Houston, Tex.
Loftin, A. D., H. N. Roberts & Associates, Lubbock, Tex.

8. Pacific

Austin, E. D. S., Stone & Webster Eng. Corp., Los Angeles, Calif.
Clark, R. A., General Elec. Co., San Francisco, Calif.
Davis, A. L., General Elec. Co., Los Angeles, Calif.
Duacsek, A. W., Ensign, USNR, FPO, San Francisco, Calif.
Franklin, W. W., Southern Calif. Water Co., Los Angeles, Calif.
Glenn, W. H., Jr., A. O. Smith Corp., Los Angeles, Calif.
Kaupp, W. J., Calif. Inst. of Tech., Pasadena, Calif.
King, B. G., Univ. of Southern Calif., Los Angeles, Calif.
Marshall, F. C., McColpin Christie Corp., Ltd., Los Angeles, Calif.
O'Roke, A. B., Pacific Gas & Elec. Co., Oakland, Calif.
Prewett, M. M., General Elec. Co., San Francisco, Calif.
Smith, A. W., Central Arizona Lt. & Pr. Co., Phoenix, Ariz.
Taylor, J. B., Calif. Inst. of Tech., Pasadena, Calif.
Wingfield, H. V., Dept. of the Interior, Los Angeles, Calif.

9. North West

Davis, F. H., Bonneville Pr. Adm., Portland, Oreg.
Lomas, G. E. (re-election), Bonneville Pr. Adm., Portland, Oreg.
Quist, F. F., General Elec. Co., Portland, Oreg.

10. Canada

Campbell, C. B., B. C. Elec. Ry. Co., Vancouver, B. C., Canada.
Hutchinson, D. C., Canadian Westinghouse Co., Calgary, Alberta, Canada.
Monty, G. J., Quebec Hydro-Electric Comm., Montreal, Que., Canada.
Morley, J. A., A. V. Roe Canada, Ltd., Toronto, Ont., Can.

Elsewhere

Bustamante, A., The Mexican Lt. & Pr. Co., Ltd., Mexico, D. F., Mexico.
Chang, L. C., Wuchang Electricity Works, Wuchang, China.
Galicia R., A., The Mexican Lt. & Pr. Co., Ltd., Mexico, D. F , Mexico.
Mier F., O. (re-election), Lascurain & Mier Co., Mexico, D. F., Mexico.
Own, K. M., Tsingtao Electricity Works, Tsingtao, Shantung, China.
Piza, J., Puerto Rico Water Resources Authority, Ponce, Puerto Rico.
Suarez F., E., Instituto Nacional Obras Sanitarias, Caracas, Venezuela, South America.
Vazquez G., L , General Elec., S. A., Mexico D. F., Mexico.
White, M. J. H., Northampton Elec. Lt. & Pr. Co. Ltd., Northampton, England.
Whitty, W. H. R., Messrs. A. Reyrolle & Co., Ltd., Heburn-on-Tyne, England.
Yu, S. C., Kweiyang Electricity Works, Kweiyang, Kweichow, China.

Total to grade of Associate
United States and Canada, 94
Elsewhere, 11

Officers and Committees for 1946–47

Officers

President

J. ELMER HOUSLEY Alcoa, Tenn.
(*Term expires July 31, 1947*)

Junior Past Presidents

CHARLES A. POWEL East Pittsburgh, Pa.
(*Term expires July 31, 1947*)

WILLIAM E. WICKENDEN Cleveland, Ohio
(*Term expires July 31, 1948*)

Vice-Presidents

District

2 E. S. FIELDS Cincinnati, Ohio
4 H. B. WOLF Charlotte, N. C.
6 L. M. ROBERTSON Denver, Colo.
8 F. F. EVENSON San Diego, Calif.
10 F. L. LAWTON Montreal, Quebec
(*Terms expire July 31, 1947*)

1 E. W. DAVIS Cambridge, Mass.
3 O. E. BUCKLEY New York, N. Y.
5 T. G. LeCLAIR Chicago, Ill.
7 R. F. DANNER Oklahoma City, Okla.
9 C. F. TERRELL Seattle, Wash.
(*Terms expire July 31, 1948*)

Directors

C. M. LAFFOON East Pittsburgh, Pa.
C. W. MIER Dallas, Tex.
S. H. MORTENSEN Milwaukee, Wis.
(*Terms expire July 31, 1947*)

P. L. ALGER Schenectady, N. Y.
M. J. McHENRY Toronto, Ontario
D. A. QUARLES New York, N. Y.
(*Terms expire July 31, 1948*)

J. M. FLANIGEN Atlanta, Ga.
J. R. NORTH Jackson, Mich.
WALTER C. SMITH San Francisco, Calif.
(*Terms expire July 31, 1949*)

J. F. FAIRMAN New York, N. Y.
R. T. HENRY Buffalo, N. Y.
E. P. YERKES Philadelphia, Pa.
(*Terms expire July 31, 1950*)

Treasurer

W. I. SLICHTER New York, N. Y.
(*Term expires July 31, 1947*)

Secretary

H. H. HENLINE New York, N. Y.
(*Term expires July 31, 1947*)

Local Honorary Secretaries

Australia—V. J. F. Brain, Department of Public Works, Bridge and Phillips Streets, Sydney, N.S.W.

Brazil—Richard H. Bowles, Sao Paulo Tramway Light and Power Company, Sao Paulo.

England—A. P. M. Fleming, Metropolitan-Vickers Electric Company, Trafford Park, Manchester 17.

India, Northern—N. Thornton, P.W.D., Electricity Branch, 11 Bahawalpur Road, Lahore, Punjab.

India, Southern—N. N. Iengar, The Tata Power Company Ltd., Bombay House, Bruce Street, Fort Bombay.

Sweden—A. F. Enstrom, Ingeniorsvetenskapsakademien, Stockholm 5.

General Committees

Executive

J. ELMER HOUSLEY, *chairman*, Aluminum Company of America, P.O. Box 465, Alcoa, Tenn.
P. L. Alger R. T. Henry
O. E. Buckley W. I. Slichter
F. Fairman W. E. Wickenden

Board of Examiners

R. H. Barclay, *chairman*, J. G. White Engineering Corporation, 80 Broad Street, New York 4, N. Y.
H. E. Farrer, *secretary*, AIEE, 33 West 39th Street, New York 18, N. Y.

P. H. Adams A. E. Knowlton
R. W. Atkinson C. M. Laffoon
Robin Beach L. G. Pacent
F. E. D'Humy J. J. Pilliod
E. D. Doyle R. C. Roe
C. W. Franklin H. M. Trueblood
I. W. Gross H. H. Weber
L. F. Hickernell John Westbye
I. F. Kinnard Sidney Withington

Code of Principles of Professional Conduct

D. D. Ewing, *chairman*, Purdue University, Lafayette, Ind.

Harry Barker D. C. Jackson
E. S. Fields S. H. Mortensen
E. H. Flath W. M. Piatt

Constitution and Bylaws

Reginald L. Jones, *chairman*, 463 West Street, New York 14, N. Y.

Mark Eldredge T. G. LeClair
W. A. Gentry Walter Charles Smith C. T. Sinclair

Edison Medal

Appointed by the president for term of five years

F. D. Newbury D. C. Prince W. E. Wickenden
(*Terms expire July 31, 1947*)
C. R. Freehafer C. A. Powel David Sarnoff
(*Terms expire July 31, 1948*)
O. E. Buckley A. E. Knowlton H. E. Strang
(*Terms expire July 31, 1949*)
C. V. Christie Zay Jeffries Harold Pender
(*Terms expire July 31, 1950*)
C. A. Corney S. M. Dean, *chairman* I. M. Stein
(*Terms expire July 31, 1951*)

Elected by the board of directors from its own membership for term of two years

J. R. North D. A. Quarles H. B. Wolf
(*Terms expire July 31, 1947*)
P. L. Alger R. T. Henry E. P. Yerkes
(*Terms expire July 31, 1948*)

Ex officio

J. Elmer Housley, president
W. I. Slichter, treasurer
H. H. Henline, secretary

Finance

D. A. Quarles, *chairman*, 463 West Street, New York 14, N. Y.
O. E. Buckley E. P. Yerkes

Charles LeGeyt Fortescue Fellowship

J. M. Gaylord R. T. Henry, *chairman*
(*Terms expire July 31, 1947*)
J. W. Barker Ernst Weber
(*Terms expire July 31, 1948*)
H. E. Strang C. H. Willis
(*Terms expire July 31, 1949*)

Headquarters

W. R. Smith, *chairman*, Public Service Electric and Gas Company, 80 Park Place, Newark 1, N. J.
H. H. Henline D. A. Quarles

Lamme Medal

W. A. Del Mar John C. Parker, *chairman* Philip Sporn
(*Terms expire July 31, 1947*)
H. L. Hazen V. M. Montsinger G. A. Waters
(*Terms expire July 31, 1948*)
N. S. Hibshman T. G. LeClair A. C. Monteith
(*Terms expire July 31, 1949*)

Members-for-Life Fund

F. M. Farmer, *chairman*, 2 East End Avenue, New York 21, N. Y.
C. R. Beardsley F. D. Newbury
E. H. Colpitts W. S. Rodman
N. E. Funk W. I. Slichter
R. C. Muir R. W. Sorensen
J. F. Tritle

Membership

Tomlinson Fort, *chairman*, Westinghouse Electric Corporation, East Pittsburgh, Pa.
F. S. Black M. L. Lehman
A. D. Brown P. H. Light
R. L. Chapman W. J. Lyman
W. F. Cotter Lee M. Moore
W. C. Fowler E. G. D. Paterson
P. H. Hughes D. B. Perry
A. W. Janowitz J. R. Riley
C. W. LaPierre H. J. Scholz
E. P. Yerkes

District Vice-Chairmen

F. S. Bacon (1) A. M. Spaulding (6)
C. T. Pearce (2) R. C. Horn (7)
J. A. Duncan, Jr. (3) E. W. Morris (8)
W. Stone Leake (4) M. J. Lantz (9)
J. C. Woods (5) Thomas Ingledow (10)

Ex officio

Chairmen of membership committees of all Sections

Planning and co-ordination

J. F. Fairman, *chairman*, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y.
P. L. Alger T. G. LeClair
G. W. Bower W. B. Morton
W. P. Dobson D. A. Quarles
H. H. Henline E. B. Robertson
M. D. Hooven C. F. Wagner
Reginald L. Jones W. E. Wickenden

Prizes, Award of Institute

M. D. Hooven, *chairman*, Public Service Electric and Gas Company, 80 Park Place, Newark 1, N. J.
C. S. Rich, *secretary*, AIEE, 33 West 39th Street, New York 18, N. Y.
J. W. Barker J. J. Pilliod
H. W. Collins J. G. Tarboux
J. D. Miner C. F. Wagner
M. S. Oldacre R. J. Wiseman
H. B. Wolf

Publication

C. F. Wagner, *chairman*, Westinghouse Electric Corporation, East Pittsburgh, Pa.
M. S. Coover F. A. Lewis
H. H. Henline J. R. North
R. K. Honaman J. J. Orr
B. M. Jones H. H. Race
G. A. Van Brunt

Publicity, Institute

R. K. Honaman, *chairman*, 463 West Street, New York 14, N. Y.
Guy Bartlett M. D. Hooven
E. E. Dorting C. R. Jones
J. F. Fairman A. E. Knowlton
C. F. Wagner

Registration of Engineers

T. G. LeClair, *chairman*, Commonwealth Edison Company, 72 West Adams Street, Chicago 90, Ill.
J. E. Hobson, *secretary*, Illinois Institute of Technology, 3300 Federal Street, Chicago 16, Ill.

S. W. Anderson — C. C. Knipmeyer
J. H. Foote — K. B. McEachron
N. L. Freeman — E. B. Robertson
J. D. Guillemette — L. M. Robertson

Research

J. W. Barker, *chairman*, Research Corporation, 405 Lexington Avenue, New York 17, N. Y.

P. L. Alger — E. L. Moreland
B. G. Ballard — G. M. L. Sommerman
E. W. Boehne — F. J. Stevens
G. T. Harness — C. G. Suits
J. A. Hutcheson — Gordon Thompson
W. A. Lewis — V. K. Zworykin

Safety

L. F. Adams, *chairman*, General Electric Company, Schenectady 5, N. Y.
Robin Beach, *vice-chairman*, 32 Court Street, Brooklyn 2, N. Y.
A. B. Smith, *secretary*, National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

C. S. Bowden — J. O. Leslie
M. M. Brandon — R. L. Lloyd
Allan B. Campbell — A. C. Muir
C. F. Dalziel — Albrecht Naeter
W. P. Dobson — W. T. Rogers
J. M. Flanigen — W. E. Rushlow
John Grotzinger — W. R. Smith
F. L. Kemp — H. W. Tenney
W. B. Kouwenhoven — E. E. Turkington
H. B. Williams

Sections

G. W. Bower, *chairman*, Public Service Electric and Gas Company, 80 Park Place, Newark 1, N. J.
R. M. Pfalzgraff, *vice-chairman*, American Viscose Corporation, Wilmington 99, Del.
A. C. Muir, *secretary*, Berwind-White Coal Mining Company, 1138 Commercial Trust Building, Philadelphia 2, Pa.

D. I. Anzini — R. E. Kistler
S. C. Commander — F. L. Lawton
W. E. Enns — C. W. Lethert
A. H. Frampton — T. M. Linville
H. P. Heafer — R. G. Porter
V. P. Hessler — C. S. Purnell
W. R. Hough — H. B. Wolf

Ex officio

Chairmen of Sections

Standards

W. P. Dobson, *chairman*, Hydro-Electric Power Commission Laboratory, 8 Strachan Avenue, Toronto, Ont.
R. L. Jones, *secretary*, 463 West Street, New York 14, N. Y.
H. E. Farrer, *secretary*, AIEE, 33 West 39th Street, New York 18, N. Y.

Joseph W. Allen — A. C. Monteith
R. C. Bergvall — S. H. Mortensen
J. E. Clem — J. R. North
C. M. Gilt — M. S. Oldacre
F. E. Harrell — E. B. Paxton
R. T. Henry — M. M. Samuels
H. E. Kent — F. B. Silsbee
Gordon Thompson

Ex officio

Chairmen of working and co-ordinating committees of the Standards committee
Chairmen of AIEE technical committees
Chairmen of AIEE delegations on other standardizing bodies or sole representatives thereon
President, United States National Committee of the International Electrotechnical Commission

Transfers

D. E. Moat, *chairman*, Leeds and Northrup Company, 1800 Keith Building, Cleveland 15, Ohio

E. A. Crellin — A. E. Knowlton
C. W. Fick — J. W. Lingary
B. D. Hull — F. K. McCune
M. J. McHenry

Student Branches

J. F. Calvert, *chairman*, Northwestern Technological Institute, Evanston, Ill.
E. M. Strong, *vice-chairman*, Cornell University, Ithaca, N. Y.

M. M. Cory — E. W. O'Brien
H. L. Davis, Jr. — L. T. Rader
A. G. Ennis — Walter Charles Smith
Everett S. Lee — R. G. Warner
C. R. Wischmeyer

Ex officio

Student Branch counselors

Technical Program

M. D. Hooven, *chairman*, Public Service Electric and Gas Company, 80 Park Place, Newark 1, N. J.
H. M. Turner, *vice-chairman*, Yale University, New Haven, Conn.
C. S. Rich, *secretary*, AIEE, 33 West 39th Street, New York 18, N. Y.

O. E. Buckley — S. H. Mortensen
F. A. Cowan — J. J. Orr
I. W. Gross — Frank Thornton, Jr.
F. E. Johnson, Jr. — C. C. Whipple
T. A. Worcester

Ex officio

J. F. Fairman, *chairman*, committee on planning and co-ordinator
L. F. Adams, *chairman*, committee on safety
W. P. Dobson, *chairman*, Standards committee
Chairmen of all technical committees

Technical Committees

Air Transportation

J. D. Miner, *chairman*, Aviation Engineering Department, Westinghouse Electric Corporation, Lima, Ohio
F. M. Roberts, *vice-chairman*, industrial engineering division, General Electric Company, Schenectady 5, N. Y.
A. F. Pelster, *secretary*, Westinghouse Electric Corporation, Lima, Ohio

J. W. Allen — O. F. Olsen
J. F. Angier — S. H. Orowski
R. A. Averitt — W. E. Pakala
C. J. Breitwieser — M. H. Peairs
Harold R. Brown — Earl G. Ports
K. D. Brumbaugh — H. F. Rempt
J. F. Calvert — Raymond Rugge
John B. Coleman — M. L. Schmidt
A. E. Corcoran — Raymond A. Smith
J. C. Cunningham — K. R. Smythe
W. T. Harding — S. D. Summers
R. M. Heintz — T. J. Tanner
V. P. Hessler — A. F. Trumbull
Chas. Kingsley, Jr. — F. H. Walker
R. A. Millermaster — W. W. West
F. O. Wisman

Automatic Stations

George S. Whitlow, *chairman*, Union Electric Company of Missouri, 315 North 12th Boulevard, Saint Louis, Mo.

J. A. Adams — E. E. George
Harris Barber — K. B. Hoffman
G. W. Bean — I. T. Knight
L. B. Bogan — G. S. Lunge
W. A. Derr — Perry Peterson
J. A. Elzi — C. H. Smoke
R. C. Ericson — J. H. Vivian
J. M. Flanigen — E. A. Williams, Jr.
M. Fraresso — C. E. Winegartner

Basic Sciences

J. D. Tebo, *chairman*, Bell Telephone Laboratories, Inc., 463 West Street, New York 14, N. Y.

J. G. Brainerd — M. G. Malti
O. E. Buckley — K. W. Miller
Charles Concordia — Brian O'Brien
H. L. Curtis — G. W. Penney
A. V. Eastman — W. E. Phillips
G. L. Greves — Walther Richter
C. R. Hanna — W. J. Seeley
H. L. Hazen — E. D. Shipley
N. S. Hibshman — James J. Smith
W. C. Johnson — V. G. Smith
H. P. Lawther — F. G. Tappan
W. A. Lewis — G. S. Timoshenko
F. C. Lindvall — Ernst Weber

Communication

J. J. Pilliod, *chairman*, American Tel. & Tel. Company, 195 Broadway, New York 7, N. Y.
Rothwell E. Smith, *vice-chairman*, Federal Tel. and Radio Corporation, 591 Broad St., Newark, N. J
H. I. Romnes, *secretary*, American Tel. & Tel. Company, 195 Broadway, New York 7, N. Y.

H. A. Affel — W. A. Jackson
A. L. Albert — C. B. Jolliffe
R. B. Beetham — H. E. Jones
H. M. Bollinger — T. L. Jones
J. D. Booth — I. J. Kaar
F. B. Bramhall — J. W. Kidder
J. L. Callahan — R. G. McCurdy
I. S. Coggeshall — G. R. Messmer
J. B. Coleman — C. W. Mier
D. I. Cone — H. H. Newell
F. A. Cowan — L. G. Pacent
H. J. Dible — Haraden Pratt
L. J. Dunnewold — G. B. Ransom
Melville Eastham — J. B. Russell
H. E. Ellithorn — R. E. Shelby
H. M. Engh — J. O. Shepherd
H. R. Fritz — C. G. Sinclair, Jr.
D. G. Geiger — Arthur Bessey Smith
E. E. George — H. M. Turner
P. C. Goldmark — Wm. Comings White
J. E. Hobson — E. P. Yerkes
F. C. Young

Domestic and Commercial Applications

Carl W. Evans, *chairman*, *Electrical South*, 1020 Grant Building, Atlanta, Ga.
M. K. Brody, *vice-chairman*, McCall's Test Rooms, 444 Madison Avenue, New York 22, N. Y.
Wesley Weinerth, *secretary*, Philadelphia Electric Company, 2301 Market Street, Philadelphia 3, Pa.

R. U. Berry — L. W. McCullough
D. K. Blake — M. J. McHenry
M. M. Brandon — H. E. Metz
A. C. Bredahl — W. F. Ogden
W. B. Buchanan — C. F. Scott
L. R. Gamble — H. P. Seelye
R. R. Herrmann — Sam Shiozawa
C. H. Leatham — G. C. Tenney
F. W. Linder — Gordon Thompson

Education

J. J. Tarboux, *chairman*, Cornell University, Ithaca, N. Y.

A. L. Albert — R. G. Porter
H. W. Bibber — Claire W. Ricker
M. S. Coover — L. M. Robertson
G. F. Corcoran — H. H. Skilling
E. E. Dreese — R. W. Sorensen
W. L. Everitt — B. R. Teare, Jr.
M. C. Hughes — George B. Thomas
E. B. Kurtz — C. E. Tucker
E. A. Loew — C. E. Tuites
A. C. Monteith — E. A. Walker
J. A. Northcott, Jr. — R. W. Warner
A. R. Zimmer

Electric Machinery

M. S. Aldacre, *chairman*, Commonwealth Edison Company, 72 West Adams Street, Chicago 90, Ill.
C. P. Potter, *vice-chairman*, Wagner Electric Corporation, 6400 Plymouth Ave., St. Louis 14, Mo.
W. C. Sealy, *secretary*, Allis-Chalmers Manufacturing Company, Milwaukee 1, Wis.

E. H. Alexander — C. J. Koch
Sterling Beckwith — T. C. Lloyd
Theodore Bratten — C. M. Lovell
F. S. Brown — G. W. McIver, Jr.
B. M. Cain — R. C. Moore
J. F. Calvert — T. H. Morgan
G. T. Harness — L. M. Robertson
F. E. Harrell — M. L. Schmidt
C. B. Hathaway — J. F. Sellers
R. A. Hopkins — H. D. Sill
W. R. Hough — H. R. Sills
E. K. Kane — F. D. Snyder
F. P. Kaspar — P. H. Trickey
C. E. Kilbourne — C. G. Veinott
L. A. Kilgore — R. L. Webb

Subcommittee chairmen

F. S. Brown, transformer
C. B. Hathaway, d-c machinery
W. R. Hough, induction machinery
C. E. Kilbourne, synchronous machinery
T. C. Lloyd, test code co-ordinating
R. L. Webb, insulation resistance

Technical Committees (continued)

Electric Welding

G. W. Garman, *chairman*, General Electric Company, 1 River Road, Schenectady 5, N. Y.

C. A. Adams
E. M. Callender
G. M. Chute, Jr.
C. N. Clark
W. E. Crawford
E. W. Davis
J. F. Deffenbaugh
G. H. Fett
K. L. Hansen
W. F. Hess
C. E. Humble
J. Harold Lampe
C. I. MacGuffie
L. B. Potter
Sam Shiozawa
C. E. Smith
H. W. Snyder
W. Spraragen
E. F. Steinert
L. K. Stringham
E. H. Vedder
J. R. Wirt
M. Zucker

Electrochemistry and Electrometallurgy

T. R. Rhea, *chairman*, General Electric Company, Schenectady 5, N. Y.

F. R. Benedict, *vice-chairman*, Room 11-L-17, Westinghouse Electric Corporation, East Pittsburgh, Pa.

W. C. Kalb, *secretary*, National Carbon Company, Inc., Carbon Products Division, P.O. Box 6087, Cleveland 1, Ohio

F. T. Chesnut
L. H. Fletemeyer
L. O. Grondahl
W. E. Gutzwiller
J. D. Harper
J. E. Hobson
Rollin Kennard
E. L. Kirk
W. B. Kouwenhoven
F. L. Lawton
D. H. Levy
Waldo Porter
J. B. Rice
Leroy W. Roush
F. O. Schnure
W. R. Schofield
N. R. Stansel
E. R. Whitehead

Electronics

W. R. G. Baker, *chairman*, General Electric Company, electronics department, Thompson Road, Syracuse, N. Y.

C. H. Willis, *vice-chairman*, Princeton University, Princeton, N. J.

W. G. Dow, *secretary*, University of Michigan, Ann Arbor, Mich.

C. T. Burke
R. S. Burnap
J. M. Cage
L. L. Call
W. R. Clark
G. J. Crowdes
A. V. Eastman
W. J. Field
William Fraser
A. P. Godsho
J. A. Green
C. C. Herskind
L. C. F. Horle
S. B. Ingram
J. P. Jordan
L. A. Kilgore
J. D. Leitch
O. W. Livingston
D. E. Marshall
H. L. Palmer
G. W. Penney
W. H. Pickering
D.A. Quarles
W. G. Roman
J. D. Ryder
E. T. Sherwood
Thomas Spooner
B. F. Tellkamp
J. T. Thwaites
F. N. Tompkins
H. M. Turner
D. C. Ulrey
E. H. Vedder
Wm. Comings White
H. Winograd

Industrial Control Devices

E. U. Lassen, *chairman*, Cutler-Hammer, Inc., 315 North 12th Street, Milwaukee 1, Wis.

J. D. Leitch, *vice-chairman*, The Electric Controller and Manufacturing Company, 2700 East 79th Street, Cleveland 4, Ohio

E. F. Mekelburg, *secretary*, industry controller division, Square D Company, 4041 North Richards Street, Milwaukee 12, Wis.

E. H. Alexander
H. H. Angel
G. S. Brown
J. A. Cortelli
R. F. Danner
W. J. Fleming
D. K. Frost
G. H. Garcelon
R. W. Jones
L. H. Matthias
M. Michel
W. W. Miller
T. B. Montgomery
J. W. Picking
L. T. Rader
C. F. Terwilliger

Light, Production and Application of

S. G. Hibben, *chairman*, The Westinghouse Lamp Division, Bloomfield, N. J.

J. F. Angier
D. W. Atwater
C. L. Dows
O. W. Holden
W. C. Kalb
C. W. Kronmiller
H. E. Mahan
G. T. Minasian
R. C. Putnam
Harris Reinhardt
E. M. Strong
C. F. Terrell
C. C. Whipple
I. A. Yost

Industrial Power Applications

Herbert Speight, *chairman*, Westinghouse Electric Corporation, 40 Wall Street, New York 5, N. Y.

S. F. French, *vice-chairman*, Anaconda Copper Mining Company, 20 Broadway, New York 4, N. Y.

L. A. Umansky, *secretary*, General Electric Company, Schenectady 5, N. Y.

E. L. Bailey
D. L. Beeman
F. R. Benedict
Philip Bliss
F. W. Cramer
H. W. Dexter, Jr.
W. H. Dickinson
D. D. Douglass
A. B. Emrick
C. Farrow
E. S. Fields
J. S. Gault
L. N. Grier
John Grotzinger
W. R. Harmer
K. W. John
Royce E. Johnson
J. P. Kennell
E. G. Morehouse
A. C. Muir
J. J. Orr
J. S. Parsons
L. C. Peterman
Kennard Pinder
L. B. Potter
Ralph Randall
Hugh L. Smith
T. O. Sweatt
E. E. Turkington
J. M. Webb
C. C. Whipple
R. T. Woodruff

Instruments and Measurements

Truman S. Gray, *chairman*, Massachusetts Institute of Technology, Cambridge 39, Mass.

E. D. Doyle, *vice-chairman*, Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia 44, Pa.

C. T. Burke, *secretary*, General Radio Company, 275 Massachusetts Ave., Cambridge 39, Mass.

R. C. Bailey
P. L. Bellaschi
P. A. Borden
H. H. Brauer
A. L. Brownlee
L. A. Burckmyer, Jr.
A. B. Craig
C. L. Dawes
F. C. Doble
W. N. Eddy
J. L. Fuller
W. N. Goodwin, Jr.
A. J. Grant
E. I. Green
I. W. Gross
C. M. Hathaway
R. D. Hickok
G. B. Hoadley
I. F. Kinnard
W. G. Knickerbocker
A. E. Knowlton
H. C. Koenig
R. J. Kryter
Everett S. Lee
J. T. Lusignan
H. C. Rankin
Claire W. Ricker
A. R. Rutter
F. B. Scott
F. B. Silsbee
G. M. L. Sommerman
E. P. Yerkes

Land Transportation

W. A. Brecht, *chairman*, transportation engineering, Westinghouse Electric Corporation, East Pittsburgh, Pa.

J. C. Aydelott
L. W. Birch
H. F. Brown
D. M. Burckett
W. J. Clardy
F. H. Craton
E. W. Davis
Llewellyn Evans
W. H. Evans
J. E. Gardner
H. C. Griffith
R. G. Thring
W. S. H. Hamilton
P. H. Hatch
G. L. Hoard
J. G. Inglis
T. M. C. Martin
P. A. McGee
E. B. Meissner
W. B. Morton
Timothy K. Murphy
A. G. Oehler
D. L. Smith

Power Transmission and Distribution

R. J. Wiseman, *chairman*, The Okonite Company, Passaic, N. J.

E. V. Sayles, *vice-chairman*, Consumers Power Company, Jackson, Mich.

I. W. Gross, *secretary*, American Gas and Electric Service Corporation, 30 Church Street, New York 7, N. Y.

Dean W. Alden
D. K. Blake
C. D. Brown
H. W. Clark
Harold Cole
S. B. Crary
H. A. Dambly
A. E. Davison
W. A. Del Mar
Robert D. Evans
W. B. Fisk
J. M. Gaylord
Herman Halperin
Edwin Hansson
K. E. Hapgood
E. R. Hendrickson
L. F. Hickernell
J. E. Hobson
J. B. Hodtum
E. K. Huntington
H. E. Kent
H. E. Wulfing
A. A. Kroneberg
W. W. Lewis
L. W. Long
J. T. Lusignan
W. D. Maddrey
R. B. Miller
Lee M. Moore
F. W. Packer
J. S. Parsons
L. M. Robertson
H. B. Robinson
R. V. Sanford
A. E. Silver
F. V. Smith
Philip Sporn
E. C. Starr
O. W. Titus
H. M. Trueblood
C. F. Wagner
E. R. Whitehead
Loyd T. Williams

Marine Transportation

W. H. Reed, *chairman*, Bruce Electric Company, 196 West Houston Street, New York 14, N. Y.

O. A. Wilde, *vice-chairman*, Sun Shipbuilding and Dry Dock Company, Chester, Pa.

W. N. Zippler, *secretary*, Gibbs and Cox, Inc., 1 Broadway, New York 4, N. Y.

E. C. Alger
W. B. Armstrong
R. A. Beekman
H. C. Coleman
P. J. DuMont
J. B. Feder
A. R. Gatewood
L. M. Goldsmith
H. F. Harvey, Jr.
R. T. Henry
W. R. Hight
J. E. Jones
R. G. Lorraine
C. Lynn
V. W. Mayer
S. N. Mead
I. H. Osborne
E. M. Rothen
E. H. Stivender
G. O. Watson
F. A. Wickel

Power Generation

M. J. Steinberg, *chairman*, Consolidated Edison Company of New York, Inc., 4 Irving Place, New York 3, N. Y.

B. G. A. Skrotzki, *secretary*, *Power*, 330 West 42nd Street, New York 18, N. Y.

C. P. Almon, Jr.
S. Beckwith
A. D. Caskey
R. P. Crippen
J. Drabelle
H. A. Dryar
J. H. Foote
A. H. Frampton
Frazer W. Gay
W. D. Hardaway
C. B. Kelley
A. J. Krupy
C. M. Laffoon
F. L. Lawton
F. M. Lewis
C. W. Mayott
J. B. McClure
G. H. McDaniel
W. S. Peterson
G. M. Pollard
R. C. Powell
G. M. Tatum
H. D. Taylor
W. R. Way
W. F. Wetmore
R. L. Witzke

Protective Devices

H. W. Collins, *chairman*, Detroit Edison Company, 2000 Second Avenue, Detroit 26, Mich.

W. A. Lewis, *vice-chairman*, Armour Research Foundation, 35 West 33rd Street, Chicago 16, Ill.

L. F. Kennedy, *secretary*, central s ation department, General Electric Company, Schenectady 5, N. Y.

H. D. Braley
W. R. Brownlee
O. E. Charlton
William Deans
H. W. Haberl
H. J. Lingal
F. R. Longley
J. R. North
H. V. Nye
H. H. Rudd
W. J. Rudge
J. H. Vivian

Subcommitee chairmen

W. R. Brownlee, relays
H. J. Lingal, circuit breakers and assembled switchgear
F. R. Longley, fault current limiting devices
H. H. Rudd, switches, fuses, and insulators
W. J. Rudge, lightning protective devices

Therapeutics, Applications of Electrity to

W. B. Kouwenhoven, *chairman*, Johns Hopkins University, Baltimore 18, Md.

L. L. Call
E. E. Charlton
F. B. Claussen
Roy Kegerreis
H. D. Moreland
H. C. Rentschler
W. R. Smith
W. I. Slichter

Institute Representatives

Aeronautical Electrical Equipment Standardization

J. R. North, liaison representative with NASC and SAE

Alfred Noble Prize Committee, ASCE

Robin Beach

American Association for the Advancement of Science, Council

J. W. Barker
I. Melville Stein

American Co-ordinating Committee on Corrosion

H. S. Phelps
J. M. Standriug, Jr.

American Research Committee on Grounding

C. T. Sinclair

American Standards Association, Standards Council

W. P. Dobson
R. T. Henry
H. S. Osborne

Alternates

H. E. Farrer
E. B. Paxton
J. J. Pilliod

(Continued on page 482)

Local Sections of the Institute

Name	District	When Organized	Membership Aug. 1, 1946	Chairman	Secretary	Secretary's Address
Akron	2	Aug. 12, '20	120	Paul S. Bechtol	A. J. B. Fairburn	College of Engg., University of Akron, Akron 4, Ohio
Alabama	4	May 22, '29	101	C. F. Sittloh	M. M. Collins	General Electric Co., P.O. Box 2602, Birmingham, 2, Ala.
Arizona	8	Mar. 22, '41	73	Irwin W. Best	F. J. Groat	Bureau of Reclamation, P.O. Box 2071, Phoenix, Ariz.
Beaumont	7	June 27, '45	75	N. C. Spencer	C. A. Daniel	P.O. Box 2870, Beaumont, Tex.
Boston	1	Feb. 3, '03	694	T. S. Gray	L. F. Cleveland	Northwestern University, 360 Hunington Ave., Boston 15, Mass.
Central Indiana	5	Jan. 12, '12	193	E. G. Hinshaw	W. H. Bollinger	1670 Allison, Indianapolis 8, Ind.
Chicago	5	1893	1,235	L. R. Janes	J. E. Hobson	Armour Research Foundation, 35 W. 33rd St., Chicago 16, Ill.
Cincinnati	2	June 30, '20	189	W. C. Osterbrock	L. H. McLaughlin	225 E. Fourth St., Cincinnati 2, Ohio
Cleveland	2	Sept. 27, '07	512	J. C. Strasbourger	H. W. Sussman	3689 Glencairn Road, Shaker Heights 20, Ohio
Columbus	2	Mar. 17, '22	94	E. D. Ayres	E. E. Kimberly	Ohio State University, Columbus, Ohio
Connecticut	1	Apr. 16, '21	435	Harry F. Brown	Elmer G. Horton	Westinghouse Electric Corp., P.O. Box 1817, New Haven 8, Conn.
Dayton	2	June 9, '43	258	W. A. Dynes	W. A. Barden	545 Daytona Parkway, Dayton 6, Ohio
Denver	6	May 18, '15	284	L. A. Stenger	M. H. Kight	U. S. Bureau of Reclamation, Denver, Colo.
East Tennessee	4	Sept. 2, '36	284	F. A. Hoeke	R. M. Alspaugh	T.V.A., Union Building, Knoxville, Tenn.
Erie	2	Jan. 11, '18	87	Lanier Greer	Wilbur C. Brown	General Electric Co., East Lake Road, Erie, Pa.
Florida	4	Jan. 28, '31	155	M. L. Barre	C. H. Summers	Florida Power & Light Co., Miami, Fla.
Fort Wayne	5	Aug. 14, '08	109	S. W. Winje	E. A. Linke	813 West Packard, Fort Wayne 6, Ind.
Georgia	4	Jan. 14, '04	179	Gordon F. Price	Robert O. Loomis	Georgia Power Co., Atlanta 1, Ga.
Houston	7	Aug. 7, '28	187	R. S. Kersh	H. C. Dillingham	Texas A. & M. College, College Station, Tex.
Illinois Valley	5	June 30, '45	80	Thomas A. Hopkins	C. T. Borchelt	1118 N. Glen Oak Ave., Peoria 4, Ill.
Iowa	5	June 29, '29	104	Richard F. Castner	Wilton R. Abbott	Iowa State College, Ames, Iowa
Ithaca	1	Oct. 15, '02	99	W. H. Erickson	P. D. Ankrum	School of Elec. Engg., Cornell University, Ithaca, N. Y.
Kansas City	7	Apr. 14, '16	193	C. Myron Lytle	Joel P. Kesler	Westinghouse Electric Corp., 101 W. 11th St., Kansas City 6, Mo.
Lehigh Valley	2	Apr. 16, '21	216	R. E. Neidig	A. L. Price	173 S. Church St., Hazleton, Pa.
Los Angeles	8	May 19, '08	900	E. W. Morris	Bradley Cozzens	P.O. Box 3669 Terminal Annex, Los Angeles, Calif.
Louisville	4	Oct. 15, '26	82	L. W. Anderson	Harry Hadsel	Amer. Elevator & Machine Co., 500 E. Main St., Louisville 2, Ky.
Lynn	1	Aug. 22, '11	217	R. G. Connors	B. M. Cain	General Electric Co., 3rd-74, 920 Western Ave., West Lynn, Mass.
Madison	5	Jan. 8, '09	90	Carl C. Crane	B. C. Lueders	532 Oak St., Baraboo, Wis.
Mansfield	2	Mar. 6, '39	60	Eric Brooke	C. W. Freeman	North Electric Mfg. Co., Galion, Ohio
Maryland	2	Dec. 16, '04	460	H. H. Angel	R. L. McCoy	Locke Insulator Corp., Baltimore, Md.
Memphis	4	May 22, '30	117	W. R. Moyers, Jr.	M. G. Sifford	Westinghouse Elec. Supply Co., 366 Madison Ave., Memphis 3, Tenn.
Mexico	7	June 29, '22	195	O. R. Enriquez	Antonio Baca	33 Palma St., Room 210, Mexico D. F., Mexico
Michigan	5	Jan. 13, '11	562	G. M. Chute	A. W. Rauth	Consumers Power Co., 212 Michigan Ave., Jackson, Mich.
Milwaukee	5	Feb. 11, '10	500	Walther Richter	F. J. Van Zeeland	Milwaukee School of Engg., 1020 N. Broadway, Milwaukee, Wis.
Minnesota	5	Apr. 7, '02	184	H. E. Hartig	Donald C. Gray	American Hoist & Derrick Co., 63 S. Robert St., St. Paul 1, Minn.
Montana	9	June 24, '31	72	E. W. Williams	N. H. Hilke	International Business Machines Co., Helena, Mont.
Montreal	10	Apr. 16, '43	245	W. R. Simmons	M. C. Thurling	Can. Gen. Elec. Co. Ltd., 1000 Beaver Hall Hill, Montreal, Que.
Muscle Shoals	4	Feb. 18, '38	23	Ernest L. Bishop	Lyle W. Jenkins	922 Glendale St., Florence, Ala.
Nebraska	6	Jan. 21, '25	60	Max Mattison	I. M. Ellestad	Northwestern Bell Telephone Co., Omaha, Nebr.
New Mexico-West Texas	7	Mar. 7, '40	68	Roy M. Walker	Oscar H. Gutsch	2717 E. Missouri St., El Paso, Tex.
New Orleans	4	Dec. 8, '33	185	F. E. Johnson	E. I. Blanchard	Louisiana P. & L. Co., 433 Metairie Road, New Orleans 20, La.
New York	3	Dec. 10, '19	4,175	J. H. Pilkington	P. C. Cromwell	New York University, University Heights, New York 53, N. Y.
Niagara Frontier	1	Feb. 10, '25	232	R. G. Harper	E. T. Nicholson	Buffalo Niagara Electric Corp., 93 Dewey Ave., Buffalo 14, N. Y.
North Carolina	4	Mar. 21, '29	174	G. F. Stratton	C. W. Moseley	1129 Greenwood Cliff, Charlotte 3, N. C.
North Texas	7	May 18, '28	272	H. K. Doyle	W. C. Fowler	Hotel Texas, Fort Worth, Tex.
Oklahoma City	7	Feb. 16, '22	133	J. L. Jones	H. E. Brashear	Southwestern Bell Telephone Co., Oklahoma City, Okla.
Philadelphia	2	Feb. 18, '03	1,067	H. A. Dambly	W. R. Clark	Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa.
Pittsburgh	2	Oct. 13, '02	772	J. B. Hodtum	A. C. Monteith	Westinghouse Electric Corp., East Pittsburgh, Pa.
Pittsfield	1	Mar. 25, '04	221	D. D. MacCarthy	W. E. Birchard	Motor Engg. Div., General Electric Co., Pittsfield, Mass.
Portland	9	May 18, '09	302	W. Morgan Allen	M. D. Duffy	Northwestern Electric Co., 920 S. W. Sixth Ave., Portland 4, Oreg.
Providence	1	Mar. 12, '20	112	C. H. Parker	G. E. Andrews, Jr.	Engg. Dept., Narragansett Electric Co., Providence 1, R. I.
Rochester	1	Oct. 9, '14	154	G. R. Town	A. F. Martin	Bauch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
St. Louis	7	Jan. 14, '03	377	O. T. Farry	R. W. Gaskins	Union Electric Co. of Missouri, 12th & Locust Sts., St. Louis 1, Mo.
San Diego	8	Jan. 18, '39	110	C. F. McCabe	H. A. Cordes	General Electric Co., 861 Sixth Ave., San Diego 1 Calif.
San Francisco	8	Dec. 23, '04	839	A. Tilles	J. L. Buckley	Pacific Gas & Electric Co., 245 Market St., San Francisco 6, Calif.
Schenectady	1	Jan. 26, '03	700	R. V. Shepherd	J. C. Page	Central Station Engg. Div., General Elec. Co., Schenectady 5, N. Y.
Seattle	9	Jan. 19, '04	310	A. V. Eastman	John M. Nelson	1015 Third Ave., Seattle 4, Wash.
Sharon	2	Dec. 11, '25	145	C. W. Miller	R. L. Brown	1619 McDowell St., Sharon, Pa.
South Bend	5	Feb. 26, '41	76	H. E. Ellithorn	A. J. Quigley	1019 N. Frances St., South Bend 17, Ind.
South Carolina	4	Mar. 2, '40	52	J. L. Weeks	Charles O. Warren	525 Woodrow St., Columbia, S. C.
South Texas	7	May 23, '30	83	O. T. Lodal	C. G. Krause	City Pub. Service Bd., 201–203 N. St. Mary's St., San Antonio 5, Tex.
Spokane	9	Feb. 14, '13	122	D. H. Olney	O. W. Hurd	Bonneville Power Administration, Title Bldg., Spokane 8, Wash.
Springfield	1	June 29, '22	66	W. S. Scheering	J. L. Hyland	Western Massachusetts Electric Co., Turners Falls, Mass.
Syracuse	1	Aug. 12, '20	160	L. J. Audlin	W. C. Jenkins	Westinghouse Electric Corp., 700 W. Genesee St., Syracuse 4, N. Y.
Toledo	2	June 3, '07	89	W. E. Boruh	W. M. Campbell	2145 Central Grove Ave., Toledo, Ohio
Toronto	10	Sept. 30, '03	466	A. R. Zimmer	H. Osborne	Ferranti Electric Ltd., Mount Dennis, Toronto, Ont.
Tulsa	7	Oct. 1, '37	100	E. F. Patterson	S. C. Wright	Southwestern Bell Telephone Co., 420 S. Detroit, Tulsa, Okla.
Urbana	5	Nov. 25, '02	53	E. A. Reid	C. A. Keener	308 Elec. Engg. Lab., University of Illinois, Urbana, Ill.
Utah	9	Mar. 9, '17	94	J. R. Jarvis	John A. McDonald	General Electric Co., P.O. Box 779, Salt Lake City, Utah
Vancouver	10	Aug. 22, '11	126	F. J. Bartholomew	F. H. Hedley	Can. Westinghouse Co. Ltd., 1418 Marine Bldg., Vancouver, B. C.
Virginia	4	May 19, '22	151	C. H. Smoke	William C. Jones	Box 1707, Norfolk 1, Va.
Washington	2	Apr. 9, '03	709	F. S. Black	Dixon Lewis	Alum. Co. of Amer., 605 Southern Bldg., Washington 5, D. C.
West Virginia	2	Apr. 9, '40	79	E. M. Hansford	W. E. Nuhfer	Appalachian Electric Power Co., Cabin Creek, W. Va.
Wichita	7	Sept. 16, '37	82	R. D. Finnell	C. W. Halferty	Kansas Gas & Electric Co., 201 N. Market St., Wichita 1, Kans.
Worcester	1	Feb. 18, '20	66	T. H. Morgan	B. F. Hammarstrom	Heald Machine Co., New Bond St., Worcester 6, Mass.
Total Sections	75		22,645			

Local Subsections of the Institute

Name	Chairman	Secretary	Secretary's Address
Local Subsections			
Albuquerque (New Mexico–West Texas Section)	W. T. Hardgrave		
Arrowhead (Minnesota Section)	R. H. Holmes	Arthur C. Smythe	Minnesota Power & Light Co., Duluth, Minn.
Boulder Dam (Los Angeles Section)	C. L. Westmann	C. L. Collins	519 Birch St., Boulder City, Nev.
Canton (Akron Section)	R. C. Wey	H. E. Rue	310 Fairview St., N. Canton, Ohio
Charleston (South Carolina Section)	Dean H. Davis	Max G. Toole	P.O. Box 42, U. S. Navy Yard, Charleston, S. C.
Charlotte (North Carolina Section)	E. Robert Davis	W. B. White	210 E. Sixth St., Charlotte, N. C.
Florida West Coast (Tampa) (Florida Section)	I. C. Matheson		
Fresno (San Francisco Section)	J. P. Price	G. A. Collins	San Joaquin Light & Power Div., Pacific Gas & Electric Co., Fresno, Calif.
Great Falls (Montana Section)		D. A. Johnson	Mt. States Tel. & Tel. Co., 401 First Ave. N., Great Falls, Mont.
Hamilton (Toronto Section)	J. F. McDiarmid	C. E. Moorhouse	Canadian Westinghouse Ltd., Hamilton, Ont.
Hampton Roads (Virginia Section)	W. G. Gardner	F. U. Ross	Virginia Electric & Power Co., Portsmouth, Va.
Jacksonville (Florida Section)	M. L. Barre		
Lake Charles (New Orleans Section)	F. I. Stalnecker	J. A. Carruth	Gulf State Utilities Co., 314 Blood St., Lake Charles, La.
Lancaster–York (Maryland Section)	H. J. Stewart	J. L. Staufler	Pennsylvania Power & Light Co., Griest Bldg., Lancaster, Pa
Little Rock (Memphis Section)	J. A. Hunter	O. W. Waller	Box 2100, Little Rock, Ark.
Miami (Florida Section)	P. J. Carlin		
Niagara Falls (Niagara Frontier Section)	G. A. Zehr	C. R. Staker	203—79th St., Niagara Falls, N. Y.
Niagara District (Toronto Section)	J. I. Gram	W. G. Barr	1888 Main St., Niagara Falls, Ont.
Ottawa (Montreal Section)	B. G. Ballard	J. H. Simpson	National Research Council, Ottawa, Ont.
Panhandle (North Texas Section)	C. V. Bullen	H. O. Hodson	Southwestern Public Service Co., 420 Polk St., Amarillo, Tex.
Richmond (Virginia Section)	W. T. Johns, Jr.	H. A. Frazier	System Engg. Dept., Virginia Elec. & Power Co., Richmond, Va
Rock River Valley (Madison Section)	R. E. Schuette	Royce E. Johnson	Barber-Colman Company, Rockford, Ill.
Sacramento (San Francisco Section)	James C. Coombs	James R. Miller	3991 Third Ave., Sacramento, Calif.
Saginaw Valley (Michigan Section)	Melvin L. Manning	Gordon S. Marvin	1007 Bradley Ave., Flint 3, Mich.
Shreveport (New Orleans Section)	W. J. Googe	W. N. Petzing	General Electric Co., 206 Market St., Shreveport, La.
Wilmington (Philadelphia Section)	F. T. Bear	E. W. Randall	E. I. du Pont de Nemours & Co., Wilmington, Del.
Zanesville (Columbus Section)	George W. Miller	George W. Cooper	917 Lindbergh Ave., Zanesville, Ohio

Geographical District Executive Committees

	District	Chairman (Vice-President, AIEE)	Secretary (District Secretary)	Chairman, District Committee on Student Activities
1	North Eastern	E. W. Davis, Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass.	Victor Siegfried, American Steel & Wire Co., Worcester 7, Mass.	E. R. McKee, University of Vermont, Burlington, Vt.
2	Middle Eastern	E. S. Fields, Cincinnati Gas & Electric Co., 4th & Main Sts., Cincinnati 1, Ohio	A. A. Johnson, Westinghouse Electric Corporation, East Pittsburgh, Pa.	P. X. Rice, Pennsylvania State College, State College, Pa.
3	New York City	O. E. Buckley, Bell Telephone Laboratories, Inc., 463 West St., New York 14, N. Y.	J. L. Callahan, R.C.A. Laboratories, Radio Corporation of America, 66 Broad St., New York, N. Y.	Harry Baum, College of the City of New York, 139th St. & Convent Ave., New York, N. Y.
4	Southern	Herman B. Wolf, Duke Power Company, Charlotte 1, N. C.	C. B. Galphin, 2312 Greenway, Charlotte 4, N. C.	Brinkley Barnett, University of Kentucky, Lexington, Ky.
5	Great Lakes	T. G. LeClair, Commonwealth Edison Company, 72 W. Adams St., Chicago 90, Ill.	N. C. Pearcy, Public Utility Engg. & Service Corp., 231 S. La Salle St., Chicago 4, Ill.	J. H. Kuhlmann, University of Minnesota, Minneapolis, Minn.
6	North Central	L. M. Robertson, Public Service Co. of Colorado, Denver, Colo.	H. F. Gidlund, Public Service Co. of Colorado, Denver, Colo.	O. E. Edison, University of Nebraska, Lincoln, Nebr.
7	South West	R. F. Danner, Oklahoma Gas & Electric Co., Oklahoma City 1, Okla.	W. B. Stephenson, Southwestern Bell Telephone Co., Oklahoma City 2, Okla.	C. L. Farrar, University of Oklahoma, Norman, Okla.
8	Pacific	F. F. Evenson, 600 E. Harbor St., P.O. Box 1710, San Diego, Calif.	Walter L. Bryant, U. S. Navy Electronics Laboratory, San Diego 52, Calif.	W. H. Pickering, California Institute of Technology, Pasadena, Calif.
9	North West	C. F. Terrell, Puget Sound Power & Light Co., 860 Stuart Bldg., Seattle, Wash.	C. H. Cutter, 814 Securities Building, Seattle 1, Wash.	E. W. Schilling, Montana State College, Bozeman, Mont.
10	Canada	F. L. Lawton, Aluminum Co. of Canada Ltd., 1700 Sun Life Bldg., Montreal, Que.	D. M. Farnham, Quebec Hydro-Elec. Commission, 107 Craig St. West, Montreal, Que.	

NOTE: Each District executive committee includes also the chairmen and secretaries of all Sections within the District, and the District vice-chairman of the AIEE membership committee.

Institute Representatives (continued from page 480)

American Year Book, Advisory Board
H. H. Henline

Charles A. Coffin Fellowship and Research Fund Committee
J. Elmer Housley

Committee of Apparatus Makers and Users, NRC
L. F. Adams

Committee on Standard Commodity Classification or Index
E. B. Paxton

Electrical Standards Committee, ASA
H. E. Farrer, A. C. Monteith, J. J. Pilliod
Alternates
W. P. Dobson, E. L. Moreland, E. B. Paxton

Engineering Foundation Board
L. W. Chubb, F. M. Farmer

Engineering Societies Monographs Committee
F. M. Farmer, W. I. Slichter

Engineering Societies Personnel Service, Inc.
H. H. Henline

Engineers' Council for Professional Development
M. S. Coover, Everett S. Lee, E. C. Stone

Engineers Joint Council
H. H. Henline, J. Elmer Housley, W. E. Wickenden

Hertz Award Committee
M. S. Coover

Hoover Medal Board of Award
H. H. Barnes, Jr., H. S. Osborne, John Castlereagh Parker

Industry Committee on Interior Wiring Design
M. M. Brandon, L. C. Peterman

John Fritz Medal Board of Award
Nevin E. Funk, C. A. Powel, J. Elmer Housley, W. E. Wickenden

Joint Committee for Development of Statistical Applications in Engineering and Manufacturing
W. P. Dobson

Library Board, United Engineering Trustees, Inc.
N. S. Hibshman, G. L. Knight, H. H. Henline, *ex officio*, H. M. Turner

Marston Medal Board of Award
Harry B. Gear

National Bureau of Engineering Registration, Advisory Board
T. G. LeClair

Institute Representatives (cont'd)

National Fire Protection Association, Electrical Committee
L. F. Adams — W. Ralph Smith, *alternate*

National Fire Waste Council
L. F. Adams — Wills Maclachlan

National Research Council, Division of Engineering and Industrial Research
W. B. Kouwenhoven

National Technological Advisory Committee
John Castlereagh Parker

Quarterly of Applied Mathematics
J. G. Brainerd

Radio Technical Planning Board
H. A. Affel

United Engineering Trustees, Inc.
W. H. Harrison — C. R. Jones — Everett S. Lee

United States National Committee of the International Commission on Illumination
W. Barker — Robin Beach — S. G. Hibben

United States National Committee of the International Electrotechnical Commission
H. E. Farrer — A. C. Monteith — J. J. Pilliod

Alternates
W. P. Dobson — E. L. Moreland — E. B. Paxton

Washington Award Commission
M. S. Coover — H. B. Gear

World Power Conference, Executive Committee of United States National Committee
J. Elmer Housley

Student Branches of the Institute

Name and Location	District	Counselor (Member of Faculty)
Akron, University of, Akron, Ohio	2	A. J. Fairburn
Alabama Polytechnic Institute, Auburn	4	
Alabama, University of, University	4	William J. Miller
Alberta, University of, Edmonton, Canada	10	R. E. Phillips
Arizona, University of, Tucson	8	J. C. Clark
Arkansas, University of, Fayetteville	7	A. S. Brown
British Columbia, University of, Vancouver, Canada	10	W. B. Coulthard
Brooklyn, Polytechnic Inst. of, Brooklyn, N. Y. (Day)	3	F. A. Wahlers
(Evening)	3	Anthony Giordana
Brown University, Providence, R. I.	1	F. N. Tompkins
Bucknell University, Lewisburg, Pa.	2	George Irland
California Institute of Technology, Pasadena	8	W. H. Pickering
California, University of, Berkeley	8	P. L. Morton
Carnegie Institute of Technology, Pittsburgh, Pa.	2	D. W. VerPlanck
Case School of Applied Science, Cleveland, Ohio	2	P. L. Hoover
Catholic University of America, Washington, D. C.	2	T. J. MacKavanagh
Cincinnati, University of, Cincinnati, Ohio	2	A. C. Herweh
Clarkson College of Technology, Potsdam, N. Y.	1	Alfred R. Powers
Clemson Agricultural College, Clemson, S. C.	4	F. T. Tingley
Colorado State Coll. of A. & M. Arts, Ft. Collins	6	C. F. Chinburg
Colorado, University of, Boulder, Colo.	6	Platt Wicks
Columbia University, New York, N. Y.	3	W. A. LaPierre
Connecticut, University of, Storrs	1	G. S. Timoshenko
Cooper Union, New York, N. Y.	3	Norman L. Towle
Cornell University, Ithaca, N. Y.	1	B. K. Northrop
Delaware, University of, Newark	2	Milton G. Young
Denver, University of, Denver, Colo.	6	Fred H. McClain
Detroit, University of, Detroit, Mich.	5	H. O. Warner
Drexel Institute of Technology, Philadelphia, Pa.	2	F. C. Powell
Duke University, Durham, N. C.	4	K. B. MacKichan
Florida, University of, Jacksonville	4	Edward F. Smith
George Washington University, Washington, D. C.	2	Milton K. Akers
Georgia School of Technology, Atlanta, Ga.	4	H. B. Duling
Harvard University, Cambridge, Mass.	1	John P. Newton
Idaho, University of, Moscow	9	J. Hugo Johnson
Illinois Institute of Technology, Chicago	5	E. T. B. Gross
Illinois, University of, Urbana	5	E. A. Reid
Iowa State College, Ames	5	B. S. Willis
Iowa, University of, Iowa City	5	E. B. Kurtz
Johns Hopkins University, Baltimore, Md.	2	F. Hamburger, Jr.
Kansas State College, Manhattan	7	Joe E. Ward
Kansas, University of, Lawrence	7	David D. Robb
Kentucky, University of, Lexington	4	Brinkley Barnett
Lafayette College, Easton, Pa.	2	Morland King
Lehigh University, Bethlehem, Pa.	2	J. L. Beaver
Louisiana State University, Baton Rouge	4	A. K. Ramsey
Louisville, University of, Louisville, Ky.	4	M. C. Northrup
Maine, University of, Orono	1	W. J. Creamer
Manhattan College, New York, N. Y.	3	Robert T. Weil
Marquette University, Milwaukee, Wis.	5	E. W. Kane
Maryland, University of, College Park	2	L. J. Hodgins
Massachusetts Inst. of Technology, Cambridge	1	D. P. Severance
Mich. College of Mining & Tech., Houghton	5	G. W. Swenson
Michigan State College, East Lansing	5	J. A. Strelzoff
Michigan, University of, Ann Arbor	5	J. S. Gault
Milwaukee School of Engg., Milwaukee, Wis.	5	E. L. Wiedner
Minnesota, University of, Minneapolis	5	J. H. Kuhlmann
Mississippi State College, State College	4	Harry C. Simrall
Missouri School of Mines & Metallurgy, Rolla	7	I. H. Lovett
Missouri, University of, Columbia	7	Clifford M. Wallis
Montana State College, Bozeman	9	G. Dale Scheckels
Nebraska, University of, Lincoln	6	O. E. Edison
Nevada, University of, Reno	8	S. G. Palmer
Newark College of Engineering, Newark, N. J.	3	William Jordan
New Hampshire, University of, Durham, N. H.	1	W. B. Nulsen
New Mexico State College, State College	7	Harold A. Brown
New Mexico, University of, Albuquerque	7	R. W. Tapy
New York, Coll. of the City of, New York, N. Y.	3	Harry Baum
New York University, New York	3	Charles F. Rehberg
North Carolina State College, Raleigh	4	C. G. Brennecke
North Dakota State Agricultural College, Fargo	5	Harry S. Dixon
North Dakota, University of, Grand Forks	5	C. W. Rook
Northeastern University, Boston, Mass.	1	Roland G. Porter
Northwestern University, Evanston, Ill.	5	R. Beam
Norwich University, Northfield, Vt.	1	F. A. Spencer
Notre Dame, University of, Notre Dame, Ind.	5	L. F. Stauder
Ohio Northern University, Ada	2	
Ohio State University, Columbus	2	
Ohio University, Athens	2	
Oklahoma A. & M. College, Stillwater	7	Albrecht Naeter
Oklahoma, University of, Norman	7	C. L. Farrar
Oregon State College, Corvallis	9	A. L. Albert
Pennsylvania State College, State College	2	P. X. Rice
Pennsylvania, University of, Philadelphia	2	S. Reid Warren, Jr.
Pittsburgh, University of, Pittsburgh, Pa.	2	R. C. Gorham
Pratt Institute, Brooklyn, N. Y.	3	Donald H. Wright
Princeton University, Princeton, N. J.	2	J. E. Paul
Puerto Rico, University of, Mayaguez, P. R.	3	Miguel Wiewall, Jr.
Purdue University, Lafayette, Ind.	5	R. B. Marshall
Rensselaer Polytechnic Institute, Troy, N. Y.	1	Emerson D. Broadwel
Rhode Island State College, Kingston	1	
Rice Institute, Houston, Tex.	7	M. V. McEnamy
Rose Polytechnic Institute, Terre Haute, Ind.	5	C. C. Knipmeyer
Rutgers, University, New Brunswick, N. J.	3	P. S. Creager
Santa Clara, Univ. of, Santa Clara, Calif.	8	W. J. Warren
South Carolina, University of, Columbia	4	Samuel Litman
South Dakota State College, Brookings	5	W. H. Gamble
South Dakota State School of M. & T., Rapid City	6	J. O. Kammerman
Southern California, Univ. of, Los Angeles	8	P. S. Biegler
Southern Methodist Univ., Dallas, Tex.	7	R. L. Biesele, Jr.
Stanford Univ., Stanford University, Calif.	8	W. G. Hoover
Stevens Inst. of Technology, Hoboken, N. J.	3	
Swarthmore College, Swarthmore, Pa.	2	J. D. McCrumm
Syracuse University, Syracuse, N. Y.	1	Leroy Mullin
Tennessee, University of, Knoxville	4	W. O. Leffell
Texas, A. & M. College of, College Station	7	N. F. Rode
Texas Technological College, Lubbock	7	
Texas, University of, Austin	7	A. J. McCrocklin, Jr.
Toronto, University of, Toronto, Ont., Can.	10	L. S. Lauchland
Tufts College, Medford, Mass.	1	A. H. Howell
Tulane University, New Orleans, La.	4	M. G. Zervigon
Union College, Schenectady, N. Y.	1	H. W. Bibber
Utah, University of, Salt Lake City	9	O. C. Haycock
Vanderbilt University, Nashville, Tenn.	4	S. R. Schealer
Vermont, University of, Burlington	1	E. R. McKee
Villanova College, Villanova, Pa.	2	Harry S. Bueche
Virginia Military Institute, Lexington	4	J. S. Jamison
Virginia Polytechnic Institute, Blacksburg	4	Claudius Lee
Virginia, University of, Charlottesville	4	L. R. Quarles
Washington, State College of, Pullman	9	H. F. Lickey
Washington, University of, Seattle	9	Vinson L. Palmer
Washington University, St. Louis, Mo.	7	D. A. Fischer
West Virginia University, Morgantown	2	A. H. Forman
Wisconsin, University of, Madison	5	G. F. Tracy
Worcester Poly. Institute, Worcester, Mass.	1	D. C. Alexander
Wyoming, University of, Laramie	6	R. O. Trueblood
Yale University, New Haven, Conn.	1	A. G. Conrad

Total Branches 126

OF CURRENT INTEREST

Electric Facilities Aid United Nations at Lake Success

The temporary quarters of the United Nations organization at Lake Success, N. Y., were used for the first time when the Security Council met on August 28, 1946. Early in July the Sperry Gyroscope Company had vacated a 650 by 650 foot portion of their wartime plant as well as their administration building at Lake Success on Long Island. Extensive alterations had been effected in the next 46 days. The entire electrical installation was planned, engineered, and supervised by Voorhees, Walker, Foley, and Smith, architects and engineers of New York, N. Y.

There are two main council chambers, each approximately 80 by 80 feet. One chamber, used by the Security Council, seats 18 delegates, 16 interpreters, 214 press representatives, and 515 members of the general audience. The other chamber, used by the Social and Economic Council, is equipped to seat a total of 750 people. Supplementing these chambers are four large conference rooms, each seating 55 delegates, 12 interpreters, and an audience of 180. Behind these main council chambers and conference rooms office space is provided for the various United Nations functions as well as the press services.

Each council chamber has been designed to have a general illumination of 58 foot-candles at the center of the room, which tapers to 35 foot-candles at the edges. Figure 1 shows the soft illumination and interesting patterns on the ceiling which are provided by continuously louvered fluorescent units suspended below the acoustically treated ceiling. A total of 24,000 watts illumination is provided in each chamber. This gives an average of 3.7 watts per square foot under the louvered section. The low-brightness 40-watt 5-foot 4,500-degree white fluorescent tubes are controlled by instant-start 2-lamp high-power-factor ballasts. To protect the critical and expensive sound system one radio interference filter is installed for each pair of lamp ballasts. Most of the light is concentrated in a downward direction by the louvers. They also provide 45-degree cutoff of direct vision of the tubes.

The removable louver frames are made of 14-gauge aluminum. Each is 66 inches long, 30 inches wide, and weighs less than 30 pounds. This arrangement greatly facilitates maintenance and replacement of lamps. Exact alignment of the centered louver frames is required to give the desired neat and precise pattern and was one of the greatest problems encountered during the construction period. These council chamber ceilings are reputed to be the largest continuously louvered ceilings in existence.

Wide World Photo

Figure 1. Temporary quarters of the security council at Lake Success

The loud-speakers and ventilation ducts are visible in the louver ceiling. A low-level loud-speaker located in the press section is visible in the upper section of the picture

Directly above the main conference table supplementary lighting is provided by 12 1,000-watt floodlights mounted in the ceiling and controlled by autotransformer type dimmers. These lights are visible in Figure 1.

Available in each council chamber are 14 radio booths, one control room, 2 photography booths, 3 motion picture booths (one of which is equipped for sound), and one television booth. Twelve-circuit lighting panels are provided to service the teletypewriters and other machinery required by the various press services. This power supply is an adaptation of the original power plug-in system installed when the area was used for manufacturing purposes.

The sound system provides an individual microphone for each delegate. Two large loud-speakers in the ceiling service the main chamber. These are supplemented by several low-level loud-speakers located at various points through the elevated press section. A regular and an emergency bus from the main amplifier room provide for sound distribution to each radio, television, and motion picture booth.

The main council chambers and the conference rooms are treated acoustically on both the ceilings and walls.

Eight 500-kva Westinghouse unit substations originally used by the Sperry company have been taken over by the United Nations. The load on these units now ranges from 52 to 80 per cent of their total capacity, thus providing a margin for future expansion and development. Westinghouse plug-in "busways" originally located in each of the 40- by 80-foot bays of the manufacturing plant were moved and concentrated at monitor locations from which plug-in circuits are taken to various lighting panels for local control of illumination and local power circuits.

The air conditioning of the original Sperry plant was modified only to accommodate the subdivisions of the council chambers, offices, and conference rooms. Electrostatic precipitators clean and filter the air used in the air-conditioning system.

Record Train Radio Contact. What is believed to be a long-distance record for radiotelephone communications between a fixed station and a train was achieved during recent tests by the Nickel Plate Road. Contact was maintained between a low power fixed station at a height of 600 feet in Cleveland, Ohio, and a radio-equipped train up to a point opposite the Bellevue, Ohio, yard office, a distance of 63 miles.

UNESCO to Work for World-Wide Scientific Unity

The 79th Congress of the United States before adjourning in July enacted a Joint Resolution authorizing the President to accept membership for the United States in the United Nations Education, Scientific, and Cultural Organization. In his statement of acceptance, the President declared: "The Government of the United States will work with and through UNESCO to the end that the minds of all people may be freed from ignorance, prejudice, suspicion, and fear, and that men may be educated for justice, liberty, and peace."

In addition to authorizing membership in UNESCO, the Joint Resolution provides for the organization of a National Commission on Education, Scientific and Cultural Co-operation, which will advise the Government and serve as a link with national private organizations in matters relating to UNESCO. The commission will have 100 members, of whom 60 will be selected by each of 60 national organizations interested in education, science, and cultural matters, and 40 will be persons selected by the Department of State. Fifty of the organizations which will select representatives on the National Commission will be named soon by the Department of State; the remaining ten organizations will be chosen later by the National Commission itself.

The constitution of UNESCO was drafted by a Conference of Allied Ministers of Education following the San Francisco Conference and was signed by 43 United Nations at a conference held in London, November 1–16, 1945.

Besides the United States 14 nations now have endorsed UNESCO. In the hope that the UNESCO constitution will receive endorsement from the minimum of 20 governments necessary to put it into operation, the Department of State participated in the meetings of the Preparatory Commission, most recent of which was held July 5–12 in London, and is planning to participate in the first meeting of the General Conference, set for November in Paris.

Assisting the Department of State in connection with the work of the Preparatory Commission was an informal advisory committee of scientists. The science advisers found more problems than they solved. Since UNESCO does not in fact exist, its organization, administration, and financial structure and resources are problematical. Under these conditions planning is difficult and must be flexible. Nevertheless, the committee set for itself two major tasks, one of which is essentially complete: It endeavored to formulate scientific projects with which UNESCO may deal profitably, and it submitted a list of suggestions to be considered by the Preparatory Commission for the agenda of the Paris meeting in November. It also will attempt to evolve machinery through which American scientists may take a direct and active part in the scientific work of UNESCO, for the latter, to be successful, must command the interest and confidence of every professional group and, ideally, of every individual scientist.

The suggestions regarding a scientific program for UNESCO were transmitted by Doctor W. Albert Noyes, Jr., chairman of the department of chemistry of the University of Rochester, N. Y., who, as the committee's representative, attended a meeting of the Subcommittee on Science of UNESCO's Preparatory Commission in London on May 31 and June 1. Doctor Noyes reported that there was a strong desire on the part of the nations represented to make UNESCO a successful organization and "to give it a program which will capture the imagination as being worth while for the long-range future." At the London meeting, projects were discussed at length, and those to which highest priority has been given because of their significance and immediacy are:

1. Facilitate the exchange of personnel, of apparatus, and of information particularly by providing foreign exchange, arranging for diplomatic passports or visas when feasible, and by providing information on locations of scientific centers, and the like.

2. Facilitate the transfer of funds when such transfer is essential to international co-operation in science.

3. Co-operate with existing international organizations, particularly international scientific unions.

4. Aid wherever possible the furnishing of apparatus and of personnel to needy countries, and particularly to start a survey of such needs.

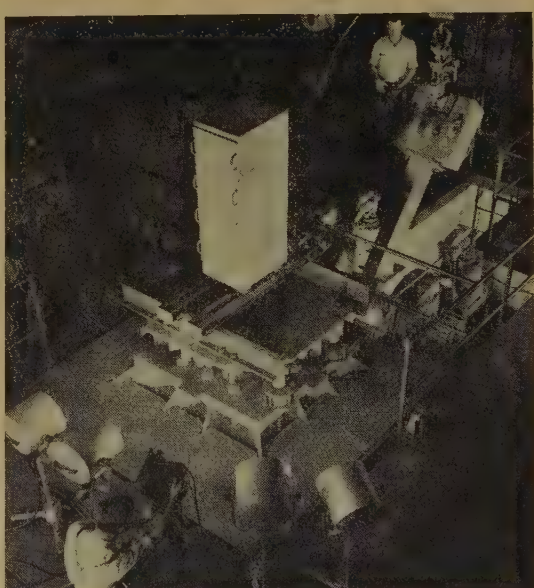
5. Provide scholarships, fellowships, and other financial aid for exchanges of personnel of various types among the co-operating countries.

UNESCO is setting for itself a program of rehabilitation and co-operation which will restore and extend the interrupted flow of scientific research. Not only does it face the task of resuscitating scientific endeavor in nations that must rebuild from their very foundations, but also of persuading national groups to co-ordinate their efforts toward common ends. It pledges co-operation with existing agencies, notably the international scientific unions, and it thus establishes itself as a co-ordinating and supplemental agency rather than as a competing entity. Not the least of its problems is that of co-ordinating its activities with the programs of other United Nations organizations, notably those dealing with agriculture and with public health, both of which deal not alone with applied science, but with fundamental aspects of biology and chemistry as well.

Exposition Concurrent With AIEE Winter Meeting

An electrical engineering exposition will be held January 27–31, 1947, at the 71st Regiment Armory, New York, N. Y., concurrently with the AIEE winter meeting. The exposition, which will feature newest developments in electrical equipment for the generation, transmission, distribution, and utilization of electric energy, is designed to be of special benefit to engineers and operating men who are responsible for the design, construction, and operation of large electric installations. Attendance will be controlled through invitations and registration; the general public will not be admitted. Originally announced for January 1941, the exposition was postponed because of the war. C. F. Roth is

Moving Pictures Now Research Tool



The operator at the left is taking moving pictures at 4,500 feet per second of a cabinet to house electric apparatus as it undergoes a 5,500 foot-pound impact test at the Westinghouse Electric Corporation, Pittsburgh, Pa. The 3,000-pound hammer in the rear has been raised to the exact height to produce the desired impact when it swings through an arc and strikes the underside of the platform on which the cabinet is bolted. When these films are projected at 16 feet per second, failures are easily analyzed

president of the company and E. K. Stevens is manager of the exposition. Other members of the advisory committee are:

J. T. Barron (F '27) vice-president, Public Service Electric and Gas Company; Walter S. Finlay, Jr. (F '21) vice-president, J. G. White Engineering Corporation; E. S. Fitz (M' 32) general manager of the electrical department, Virginia Electric and Power Company; N. E. Funk (F '34) vice-president, Philadelphia Electric Company; C. W. Leihy (M '38) of *Electric Light and Power;* A. L. Penniman, Jr. (F' 43) general superintendent of electric operations, Consolidated Gas Electric Light and Power Company of Baltimore; W. A. Perry (M '38) assistant to the general superintendent, Inland Steel Company; R. C. Roe (F '33) Burns and Roe, Inc; R. W. Wilbraham (F '45) chief electrical engineer, United Engineers and Constructors, Inc.; and S. B. Williams (M '37) of *Electrical World.*

Underwriters' Consider Use of Aluminum Conductors

Because present shortages in copper supply have stimulated proposals for the use of aluminum wire as conductors for insulated wires and cables as covered by sections 1109 and 3107 of the National Electrical Code, the Underwriters' Laboratories, Inc., has prepared the following list of the special considerations which the use of aluminum demands. The code, it is pointed out, assumes that conductors will be of copper.

Conductivity. The value of 84 per cent of that of copper specified in section 3107 of the code may be accepted.

Conductor Size. For the conductors of branch circuits that are fused at 15 amperes, number 12 American wire gauge aluminum wire should be used, instead of number 14. (On this account larger sizes of raceways may be necessary for the same number of conductors.)

Many appliances and devices with binding screw type terminals do not accommodate readily a number 12 Browne and Sharp gauge wire, and, obviously, for branch circuits of greater current ratings, larger aluminum conductors will not be accommodated by them.

Electrolytic or Galvanic Effect. Most appliances and devices have copper or brass terminals for wire connections. Because of the electrolytic effect, aluminum conductors secured to such terminals may be severely or completely corroded by such contact between these dissimilar metals. There is some field experience demonstrating this, and laboratory tests confirm the possibility. This effect is a fundamental property because of the positions of copper, its alloys, and of aluminum in the electromotive scale.

Moist atmospheres act as electrolytes, especially near the seacoast or in inland industrial areas. Several of the occupancies listed in section 3003 of the code, wherein corrosion may be expected, involve conditions favoring the electrolytic effect.

At equipment terminals that do not employ binding screws, electrical connection generally is made by soldering lugs or by pressure connectors. At present such terminal fittings are not generally available except in copper or brass. In moist atmospheres the electrolytic effect may develop in due time with connections of these types, unless inserts of a neutral metal such as zinc, or other special methods, are used. The mechanical and electrical reliability of such connections depend upon practices and workmanship not as yet generally employed. Dressing connections with coatings to exclude air from contact areas may not be a permanent measure.

Soldering. Suitable solders and soldering fluxes for joints between aluminum conductors or between such conductors and terminal fittings of other metals are not commonly available, and knowledge of the use of those that are available is limited.

Voltage Drop. Because of lower conductivity the effect of voltage drop must have special consideration in layouts of wiring and loads.

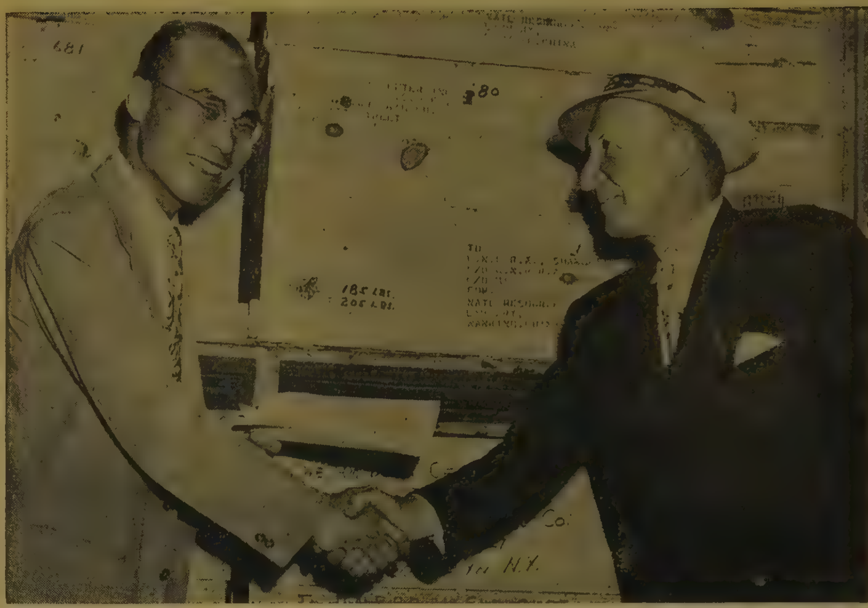
Melting Point. The lower melting point of aluminum will produce different effects under short-circuit conditions. Very likely burnouts in raceways and fittings of other metals from accidental grounds will be less frequent and less severe.

In delineating its position, the Laboratories declared that these conditions might justify deferring recognition of building wires with aluminum conductors. However, it stated that certain phases of the present conditions approach the status of an emergency which may warrant special action by all concerned, including inspection authorities having jurisdiction. However it warns that the possible appearances of some of the phenomena discussed, perhaps long after the emergency has passed, should not be ignored.

This dubious view is qualified by the statement that "it seems clear that in many areas and in various premises in perhaps other areas, conditions likely to favor corrosion troubles because of this emergency substitution never may be present. Perhaps the sum total of premises where the substitution will not add to hazards to life and property greatly exceeds that of those where trouble may be anticipated."

In conclusion the Laboratories announce that its Electrical Council and manufacturers of building wires have been informed that effective September 1, inspected rubber-covered wire labels may be used on number 12 conductors and larger.

Engineering Books Presented to China



Doctor C. D. Shiah (left), representative of the National Resources Commission of China, thanking Stewart E. Reimal of the International Relations Committee of Engineers Joint Council for shipment of more than 4,000 items of engineering literature (EE, July 1946, pp 360-1)

Facsimile Newspaper Trial Set for Early Next Year

That limited transmission of facsimile newspapers in at least a dozen cities is planned for early in 1947 was revealed recently by the General Electric Company.

The company announced that it had received an order for transmitters and receivers from John V. L. Hogan (M '20) president of Radio Inventions, Inc., on behalf of Broadcasters Faximile Analysis, an organization of 22 broadcasters and newspapers. The equipment to be manufactured was developed for this group by Radio Inventions and demonstrated to the press last spring (*EE, June '46, p 292*).

Although it is not certain which newspapers and radio stations will experiment immediately with the medium, the follow-

ing have ordered varying amounts of equipment:

Station WOR, New York; WQXR, the *New York Times* station; the *Baltimore News Post;* the *Washington* (D. C.) *Post;* the *Boston Globe;* WGN, the *Chicago Tribune* station; WNBH, New Bedford, Mass., the *Standard Times* station; WDRC, Hartford; KMBC, Kansas City; the *Toronto Globe and Mail;* the Columbia Broadcasting System; the *St. Louis Star-Times* station; KYW, Philadelphia; WFIL, Philadelphia; WOKO, Albany; the *Detroit Free Press;* the *Akron Beacon Journal;* and the *Miami Herald.*

Egyptian Commission Tours U. S. and Canada

In connection with its pending decision on bids for the building of a hydroelectric station at the Aswan Dam on the Nile River, the Hydroelectric Power Commission of the Egyptian Government visited engineering companies and major hydroelectric power stations in the United States and Canada during a trip lasting from August 5 to September 10.

Invitations for tenders on the Nile project were circulated in January 1946 and were extended to firms in Great Britain, the United States, Switzerland, France, Sweden, and Russia. The closing date for the submission of tenders is October 31. Cost of building the station has been estimated at $40,000,000, excluding the transmission. Output to be obtained from the project will be 280,000 kw, of which 100,000 kw will be available throughout the year and the remaining 180,000 kw for nine months of the year.

Doctor Abdel Aziz Bey Ahmed, chairman of the commission, was of the opinion that modern American excavation equipment would be especially suited to another project, the Quattara Hydroelectric Scheme, currently being studied by the commission. The commission is considering making a cut from the Mediterranean to the Quattara depression which lies west of the Nile delta at 450 feet below sea level. Sea water flowing into the depression as a result could be used to generate power.

Other members of the commission are: Mustafa Bey Fathy, Undersecretary of the Ministry of Public Works; A. Khairy Bey, Director of Reservoirs, Ministry of Public Works; and Geoffrey F. Kennedy, partner in the London firm of Kennedy and Donkin, consulting engineers.

Radiotelephone Aids Train Operation. That the use of radio on freight trains contributes to greater efficiency of operation is indicated by a series of tests conducted by the Western Electric Company in cooperation with the Northern Pacific Railway Company. The tests were made on runs between Seattle and Yakima, Wash., a distance of about 145 miles and between Seattle and Portland, Oreg., a distance of about 180 miles. Besides savings in time, more satisfactory operations were assured in pulling into sidings to let other trains pass, ascertaining whether or not the rear end of the train was completely on the siding, picking up additional cars, picking up trainmen, preparing for cut-in of helper engines, switching operations, and train-to-yard contacts. The equipment used consisted of a radio transmitter and receiver, handset type microphone with push-to-talk button, loud-speakers and control unit, power supply comprising a generator and inverter, and a quarter wave vertical antenna with ground plane. The equipment was installed in two Diesel-electric locomotives and in two steam locomotives and in an engine house for wayside station testing.

New Superconductor Reported. Development of metal ammonia solutions, which, after rapid freezing, are superconductive at temperatures as high as minus 85 degrees centigrade has been reported by Doctor Richard A. Ogg, Jr., of Stanford University. The materials are liquid ammonia solutions of alkali metals (such as lithium, sodium, and potassium) and alkaline earth metals (barium, calcium, and strontium). As a clue to the mechanism of superconductivity, it has been noted that in these solutions two electrons will hold together without a nucleus, whereas ordinarily two atomic nuclei would be held together by two electrons.

Army's New Flight Trainer. A new and advanced type of electronic flight trainer for instrument flight and radio navigation instruction has been developed for the Army Air Forces by Curtiss-Wright Corporation. As the trainer easily can be adapted for instruction in flying any model airplane, it is expected that in more general use it will reduce greatly the cost to airlines of training pilots for operation of new type airplanes. In appearance the Dehmel AT-6 trainers purchased by the AAF resemble a single-seat airplane fuselage, minus wings and tail section. The enclosed fuselage contains the pilot's seat, aircraft controls, and lighted instrument panel. An amplifier provides variable engine noises such as occur in flight. It is unnecessary to turn or bank the fuselage, as an electronic computing system, similar to those in electronic gun directors, translates the operation of the rudder, throttle, elevator, and other controls into the instrument readings that would guide a pilot in actual flight.

EDUCATION...

Plea for Teachers' Pay Increase. American youth cannot be properly educated for an atomic age until high school science teachers are paid higher salaries than janitors and milkmen, according to a recent statement by Doctor Paul E. Klopsteg, chairman of the American Institute of Physics and director of the Technological Institute of Northwestern University. "The discrepancy between teachers' salaries and incomes in other occupations is much wider in the United States than in other countries," he added. "This means that there is less incentive, relatively, for the best brains to enter teaching." Recent surveys, Doctor Klopsteg said, have shown that the average teacher salary is about $1,500 a year, and most high school teachers receive less than $2,000. In conclusion Doctor Klopsteg stressed the need for good teaching at the high school level as fundamental in inspiring students to undertake scientific careers and in instilling a familiarity with science basic to modern good citizenship.

Iowa Offers Course in Quality Control. An intensive ten-day course in quality control by statistical methods is being offered October 15–25 by the University of Iowa, Iowa City. A follow-up program in which two two-day clinics will be held with the industrial representatives to discuss common problems and to obtain additional information is planned. This is the fourth such course given by the university since October 1944. It is designed for executives and persons in an advisory position where the knowledge gained can be applied immediately. The course consists of a series of conferences, lectures, and laboratory periods lasting from 8:30 a.m. to 5 p.m. each day except Sunday. General lectures will be given to the entire group. However, to facilitate the discussion of specific problems and the working of laboratory exercises, the trainees will be divided into small sections under the direct supervision of an instructor. The tuition for the course including books and supplies is $100. Trainees will be expected to provide for their own living expenses and transportation. Additional details may be secured from Professor Earle L. Waterman, College of Engineering, State University of Iowa.

New Engineering Physics Degree. A department of engineering physics with a five-year curriculum leading to the degree of bachelor of engineering physics has been started at Cornell University with the 1946 fall term. The department is designed to meet industry's demand for men with broad training in engineering and physics to work in industrial research and development. Students will have wide latitude in selecting specialties within the curriculum, such as atomic physics, optics, electronics and ionics, ultrahigh frequencies, elasticity and stress analysis, and aerodynamics.

Education Quarterly at Iowa. Announcement has been made by the University of Iowa of the forthcoming publication of a quarterly devoted to "expression of the newest thought in the field of general edu-

cation, from the secondary school to the graduate or professional unit of the university." Dean Earl James McGrath of the college of liberal arts of the University of Iowa is the editor of the new *Journal of General Education*, which will be issued October 1, January 1, April 1, and July 1. Subscription rates are $2 per year and the business address is University Hall, Iowa City, Iowa. The board of editorial consultants consists of Byron S. Hollinshead, B. Lamar Johnson, Lennox Grey, W. H. Cowley, Raphael Demos, W. E. Wickenden (F '39), Doak S. Campbell, Lewis Mumford, William P. Tolley, T. R. McConnell, Robert J. Havighurst, and John W. Harbeson.

INDUSTRY.....

Brown Boveri Affiliate Formed. Formation of the Brown Boveri Corporation under the laws of New York State as an affiliate of Brown, Boveri and Company, Ltd., Baden, Switzerland, recently was announced. The new corporation, headquarters of which are in New York, N. Y., expects to intensify dissemination of data and information on new Brown Boveri products and to furnish assistance in solving operating and repair problems where needed. Paul R. Sidler (A '31) formerly resident engineer in New York for the Swiss company, is president of the new company.

Scrap Shortage Slows Production. A campaign to impress industry with the urgency for cleaning scrap metals out of industrial establishments is being conducted by the American Iron and Steel Institute. Recently 25 to 30 open hearth steel furnaces in which scrap normally makes up 50 per cent of the charge have been shut down, receipts of scrap are declining, and inventories at mills are near the vanishing point. As a result industrial production in general is threatened.

Underwater Search for Oil by Radar. The Standard Oil Company, Ltd., a subsidiary of the Standard Oil Company of New Jersey, soon will start a search for oil under the 2,000 square miles of water in the northwestern Bahamas with the aid of diving chambers equipped with radar. In much of the area to be prospected the ocean is less than 20 feet deep.

JOINT ACTIVITIES

Milwaukee Engineers Open New Headquarters

A week of events celebrating the opening of the new headquarters of the Engineers' Society of Milwaukee culminated in a banquet on September 21 attended by 1,600 engineers and friends. Principal speaker at the dinner was Doctor Charles F. Kettering (F '14) vice-president in charge of research for General Motors Corporation, whose topic was "The Challenge and Opportunities of Tomorrow."

Plans for the new headquarters were commenced in 1944 with the purchase of the mansion of Frederick Pabst, nationally known brewer. A subsequent campaign raised $100,000 from more than 100 contributing firms to defray the cost of remodeling and equipping the building. Although the architectural style of the original structure has been retained, such improvements as indirect lighting and acoustical ceiling have been added. The building now contains three small auditoriums, two of which may be expanded to one large hall by means of a sliding wall, a library and reading room, offices, committee meeting rooms, lounges, two dining rooms, and recreation and powder rooms for women.

The Milwaukee Society has a membership of 1,366 and affiliated with it are the local sections of the following national societies: the AIEE, the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Society of Refrigerating Engineers, the American Society of Heating and Ventilating Engineers, the Institute of Radio Engineers, and the Illuminating Engineering Society.

Officers of local affiliated societies attending a recent board meeting of the Engineers' Society of Milwaukee. Seated left to right are: L. W. Butler, IRE; F. J. Van Zeeland (M '44) AIEE; E. T. Sherwood (M '44) IRE; Walther Richter (F '42) AIEE; Charles W. Yoder, ASCE; Lloyd D. Knapp, ASCE; Edward W. Schmidtman, ASCE; Del C. Albright, ASRE; Standing left to right are: Phil Laeser, IRE; Ernest F. Vilter, ASRE; Edwin H. Cordes, IRE; Herbert F. Wareing, IRE

Artist's sketch of the new headquarters of the Engineers' Society of Milwaukee

OTHER SOCIETIES •

Symposium on Fluorine Sponsored by Chemical Society

How wartime research completed the previously unsolved problem of controlling fluorine gas for practical purposes was disclosed in great detail at a symposium conducted September 11, 12, and 13 in connection with the 110th national meeting of the American Chemical Society in Chicago, Ill.

The 51 papers presented at the symposium described the wartime scientific and technological advancement in the generation of fluorine and the preparation of fluorine compounds, especially fluorcarbons, or organic compounds composed of only carbon and fluorine. Small scale production and handling of fluorine also were discussed.

As much of the research was carried out as part of the atomic bomb project, some of the findings still are classified as secret by the Army. The development of anhydrous hydrofluoric acid as a catalyst made possible the production of the huge quantities of high octane aviation gasoline for war use.

It was pointed out by Professor Earl T. McBee of Purdue University, who presided at the symposium, that before the war fluorine was generated in gram quantities with difficulty, while it is now available on a large scale. The technology has advanced so far, according to Professor McBee, that fluorcarbons, extremely stable noninflammable substances which prior to the war were a laboratory curiosity, now may be made commercially.

Among the suggested benefits from the conquest of fluorine are: improved plastics, anesthetics, insecticides, fungicides, fumigants, germicides, fire extinguishers, fireproofing materials, and weed killers. A lubricating oil, so stable it will permit construction of engines hitherto impossible because no known lubricant could withstand their pressure and friction, also has been predicted. A gas already developed, but requiring elemental fluorine for its production, is expected to be an almost perfect insulator for high voltage electricity.

Farm Electrification Conference. A National Farm Electrification Conference with the objective of bringing "together in conference individuals and groups interested in raising farm living standards and reducing farm production costs by increasing the profitable uses of electricity on farms" will be held November 7 and 8, 1946, in the Sherman Hotel, Chicago, Ill. The conference is sponsored by the National Electrical Manufacturers Association, the National Electrical Wholesalers Association, the Edison Electric Institute, the American Society of Agricultural Engineers, Agricultural Editors, the National Grange, and the American Society of Mechanical Engineers. Chairman of the attendance and advance registration committee is Frank E. Watts, 420 Lexington Avenue, New York 17, N. Y.

ASME Elects New Officers. Election of officers for 1947 has been announced by the American Society of Mechanical Engineers. The new officers are:

President—Eugene W. O'Brien (M '37) vice-president, W. R. C. Smith Publishing Company, Atlanta, Ga.

Vice-Presidents—Alton C. Chick, A. R. Mumford, E. E. Williams, T. S. McEwan, and Linn Helander.

Directors at Large—F. S. Blackall, Jr.; B. V. E. Nordberg; L. F. Moody; and W. A. Carter.

Lead Makes Infrared Rays Visible. Infrared rays are made visible by the presence of lead in a phosphor, Doctor Gorton R. Fonda of the General Electric Company reported in a recent paper in the *Journal* of the Optical Society of America. The discovery may point the way to new equipment with which to see in the dark similar to the "sniperscope" and snooperscope" developed during the war. Doctor Fonda obtained his results with zinc sulfide provided it contained a fraction of a per cent of lead. Preliminary exposure of the phosphor to ultraviolet rays sends electrons from their normal orbits to higher states. With phosphorescence their return to a normal state is delayed until they are released by infrared rays. A light, green in color, is given off in this process.

Future Meetings of Other Societies

American Society of Tool Engineers. Semiannual national convention, October 10–12, 1946, Pittsburgh, Pa.

American Welding Society. Annual meeting, November 17–22, 1946, Atlantic City, N. J.

Electrochemical Society. Fall meeting, October 16–19, 1946, Toronto, Ontario, Canada.

Iron and Steel Exposition. October 1–4, 1946, Cleveland, Ohio.

National Electrical Contractors Association. Annual meeting, October 14–18, 1946, Atlantic City, N. J.

National Electrical Manufacturers Association. Annual meeting, October 28–November 1, 1946, Atlantic City, N. J.

National Electronics Conference. October 3–5, 1946, Chicago, Ill.

National Exposition of Power and Mechanical Engineering. December 2–7, 1946, New York, N. Y.

National Electronic Radio and Television Exposition. First annual, October 14–19, 1946, New York, N. Y.

National Research Council. Conference on Electrical Insulation, November 7–9, 1946, Johns Hopkins University, Baltimore, Md.

Refrigeration Equipment Manufacturers Association. Fourth refrigeration and air conditioning exposition, October 29–November 1, 1946, Cleveland, Ohio.

Society of Motion Picture Engineers. 60th semiannual convention, October 21–25, 1946, Hollywood, Calif.

Television Broadcasters Association, Inc. Second conference and exhibition, October 10–11, 1946, New York, N. Y.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Engineer-to-Be Looks Ahead

To the Editor:

And lo, a child shall lead them! Reading over the following composition gave me much material for thought. If our son, brought up to believe that each one of us is given a special talent which must be developed for the good of his fellow man, has thoughts about reaction motors and spaceships of terrifying destructive powers, how about similar dreamers who are not imbued with the thought of using that power for good?

When our son—who wrote this as a composition for his English class in high school on his 17th birthday—was 13, he badgered his engineer father to let him attend a series of lectures on nuclear physics given by an engineer from Bell Telephone Laboratories. He would rush home, change into his best clothes, dash for the citybound bus, and meet his dad for dinner near the Engineering Societies Building. He and his Dad would discuss the lectures like contemporaries.

Your magazine is pounced on immediately, when it arrives each month. And our Robert is deep in "experiments" which make me hold my breath and cross my fingers that he doesn't blow up along with his "rockets." It occurred to me there might be room for a bit of the lighter side of life in your austere magazine. If so, unbeknown to either my engineer husband or my son, I send you the composition, because I do think it is astonishing and may be more truth than poetry.

Robert is now so tall, that he is taken for 21. Though he is just 17 he is a contempo-

rary of his Dad's when they speak of electonics, nuclear physics, ionoscopes, plutrons, neutrons, and the rest—all of which is beyond my ken—my field being home-making and gardens, into which I hope no rocket ever falls.

Forgive me, but we are entering this atomic age with our youth agitated and deeply concerned about the future. What our son has written may well be an indication of what other minds, less altruistic, also may be dreaming.

DOCTOR EIMER'S ROCKET

Finished! At last, after years of toil. Now Doctor Eimer would show those skeptical scientists. For the last ten years he had put all his efforts into the development of reaction motors. They had laughed at him when he claimed he would build a spaceship large enough and powerful enough to leave the earth. They spurned him when he asked for technical assistance.

It was way back in 1945 when Doctor Eimer began teaching physics and chemistry at the university that he had become interested in rockets. He read about the famous German V-2 rockets and decided to start experimentation. When Doctor Eimer's advanced students learned of his activities many decided to earn their research credits by assisting him. So Doctor Eimer really had not been too badly off. He had had all those eager young minds to help him.

In the following years, Doctor Eimer made many experiments, some successful, but even more unsuccessful. Doctor Eimer made many contributions to science through his experiments. He built and successfully operated metereological rockets that ascended to heights of several hundred miles and brought down information on the constitution of the atmosphere and the ionized layers of air which protect us from the sun. These rockets, however, were all alike in that they used energy from chemical reactions to propel them. Mainly the oxidation of alcohol by liquid oxygen. This was satisfactory for small rockets, but for large rockets the volume of fuel would necessitate a rocket of gigantic proportions —a factor which would make it inconceivable on this earth due to air resistance. Therefore Doctor Eimer turned to the only other source of energy, that energy which is released by nuclear reactions within the atom. But Doctor Eimer had still another problem. This energy was released as heat, not as volume of gas. Doctor Eimer, therefore, had to transform this heat into something which could be harnessed. After more experiments Doctor Eimer turned to lead, a fairly common metal having a low melting point and a great density. That was the answer. He would design a uranium motor that would vaporize lead.

So now, after ten years of effort, he had completed an atom-powered rocket capable of leaving the earth. It was over 75 feet long and ten feet wide at its greatest width. But Doctor Eimer had incorporated another unique item. It was two rockets in one. There was the big main rocket, and up in the top was a smaller rocket, the one which actually would reach the moon. Loaded in the head of the small rocket was a large quantity of powdered plaster which would leave a large white spot on the moon when it hit. The two-step rocket was mounted on a launching rack on the top of Mount Rainier. When all was ready on the fateful instant Doctor Eimer pushed the button which started the rocket's motors.

What would happen? Would it tear a gigantic hole in the earth, or would it reach the moon? No one knew.

* * *

But one thing is certain. Someday, someone will push such a button and the future of the world will be altered to a terrifying degree.

K. F. ZIMMERER

(Mineola, N. Y.)

English Engineer Seeks American Correspondent

To the Editor:

If it is at all possible I would like you to put me in touch with a young American engineer of approximately my own age (recent graduate), preferably residing in the New York area, with whom I could exchange correspondence. The reason for making this request is that I wish to obtain employment in the United States at some time in the future and would like to establish some contact and learn something of American methods before doing so.

ALFRED R. POLLARD

(9, Bullsmoor Gardens, Waltham Cross, Middlesex, England)

Evaluation of Circuit Constants From Oscillograms

To the Editor:

The shape of an oscillogram may depend in a large measure upon the values of the resistance, the inductance, and the capacitance present in the circuit. This investigation was made to determine whether the effects of these circuit factors upon the shape of the oscillogram were such as to permit the determination of these factors by an analysis of the oscillogram. Formulas are derived and applied to typical oscillograms of transients in series circuits, and it is shown that the results have an accuracy which makes the formulas and the method useful.

The oscillograph generally is used qualitatively, but its use quantitatively has been quite limited. Obviously, the accuracy of determinations made from an oscillogram is dependent upon the damping of the oscillograph element, the uniformity of the film speed, the warping of the film and of its print, the accuracy of the comparative scales on the record, and upon the care used in making measurements on the record. For the quantitative evaluation of R, L, and C the times, the instantaneous values, slopes, and areas must be measured from the oscillogram. The determination of a slope is subject to a relatively large error as at a point it is a matter of estimation by the eye.

To determine whether oscillograms under certain circumstances, could be analyzed to evaluate the circuit constants, or factors, and whether, if such analysis is feasible, the accuracy would be satisfactory, the writer, with the help of students, undertook the study here presented.

Case I. Given an oscillogram similar to Figure 1, with the impressed voltage E a known constant; to determine the R and the L of the circuit.

Since the general equation

$$i=\frac{E}{R}\left(1-e^{\frac{-Rt}{L}}\right)$$

must hold for all values of t, the time, the three arbitrary sets of conditions for t_1, t_2, and t_3 can be applied, so

$$i_1=\frac{E}{R}\left(1-e^{\frac{-Rt_1}{L}}\right) \tag{1}$$

$$i_2=\frac{E}{R}\left(1-e^{\frac{-Rt_2}{L}}\right) \tag{2}$$

$$i_3=\frac{E}{R}\left(1-e^{\frac{-Rt_3}{L}}\right) \tag{3}$$

If these are rewritten to

$$e^{\frac{-Rt_1}{L}}=1-\frac{i_1R}{E},\ e^{\frac{-Rt_2}{L}}=1-\frac{i_2R}{E}$$

and

$$e^{\frac{-Rt_3}{L}}=1-\frac{i_3R}{E}$$

and for equations 1 and 2 natural logarithms are taken,

$$\frac{-Rt_1}{L}=\log\left(1-\frac{i_1R}{E}\right)$$

and

$$\frac{-Rt_2}{L}=\log\left(1-\frac{i_2R}{E}\right)$$

and R/L is subtracted and factored out

$$\frac{R}{L}\left(t_2-t_1\right)=\log\left(\frac{E-i_1R}{E-i_2R}\right) \tag{4}$$

by symmetry

$$\frac{R}{L}\left(t_3-t_2\right)=\log\left(\frac{E-i_2R}{E-i_3R}\right) \tag{5}$$

Now, if the time intervals t_2-t_1 and t_3-t_2 are equal, equation 4 divided by equation 5 yields

$$1=\frac{\log\dfrac{E-i_1R}{E-i_2R}}{\log\dfrac{E-i_2R}{E-i_3R}}$$

and with the numerator and the denominator equal there results

$$R=\frac{E[2i_2-(i_3+i_1)]}{i_2^2-i_1i_3} \tag{6}$$

Equation 2 can be written

$$L=\frac{-Rt_2}{\log\left(1-\frac{Ri_2}{E}\right)} \tag{7}$$

which completes the solution for the two circuit factors R and L under the conditions given.

If the oscillogram represents a current subsidence and has the form of Figure 2, the current is

$$i=\frac{E}{R}e^{\frac{-Rt}{I}}$$

and at $t=0$, $R=\frac{E}{i}$, and to find L

$$\frac{Ri}{E}=e^{\frac{-Rt}{L}}$$

or

$$\frac{-Rt}{L}=\log\frac{Ri}{E}$$

Substituting for the two values of time t_1 and t_2 the corresponding currents, i_1 and i_2, yields

$$L=\frac{R(t_2-t_1)}{\log\frac{i_1}{i_2}}$$

If di/dt can be evaluated at $t=0$

$$\frac{di}{dt}=-\frac{E}{L}e^{\frac{-Rt}{L}}$$

it becomes $-E/L$ and

$$L=-\frac{E}{di/dt}$$

using di/dt at $t=0$.

Case II. Given an oscillogram similar to Figure 3, with a known constant voltage of E, to determine R and C. Except for signs, the charging and the discharging currents may be represented by

$$i=\frac{E}{R}e^{\frac{-t}{CR}}$$

and at $t=0$, $R=E/i$. If the currents i_1 and i_2 are substituted into the general formula for the two values of time t_1 and t_2 and natural logarithms are taken,

$$C=\frac{t_2-t_1}{R\log\frac{i_1}{i_2}}$$

Case III. In considering oscillograms of circuits having R, L, and C in series, separate treatments are given to the oscillatory, critical, and logarithmic cases.

For the oscillatory case, with an oscillogram of the form of Figure 4: The natural frequency is

Figure 1

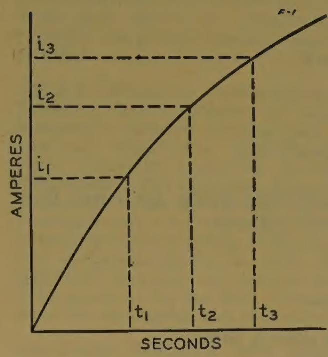
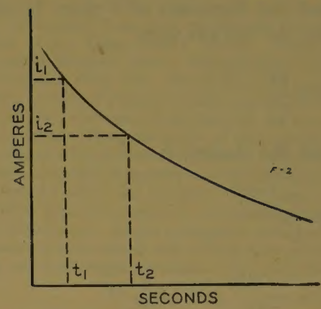


Figure 2



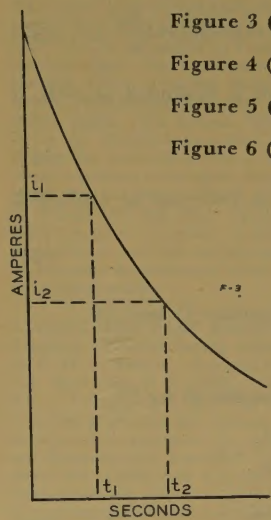
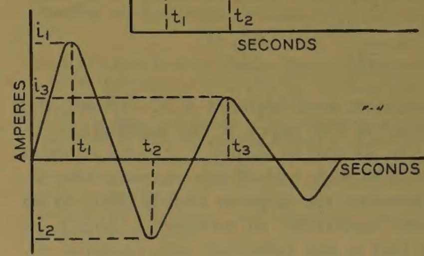


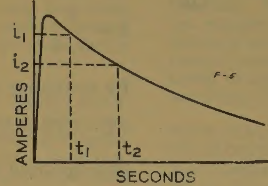
Figure 3 (left)

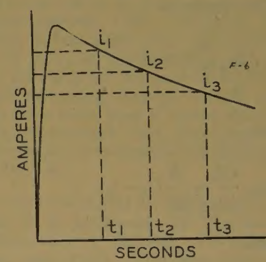
Figure 4 (right)

Figure 5 (below)

Figure 6 (below right)







$$f=\frac{\sqrt{4LC-C^2R^2}}{4\pi LC}$$

so that the time T, between adjacent zero values of current is

$$T=\frac{2\pi LC}{\sqrt{4LC-C^2R^2}} \tag{8}$$

a value to be scaled from the oscillogram by means of the timing curve.

The ratio between the amplitudes at t_2 and t_1 is the decrement factor which is

$$\delta=e^{-\frac{R}{2L}(t_2t_1)}$$

whence, by natural logarithms

$$\frac{R}{2L}=\frac{-\log\delta}{t_2-t_1} \tag{9}$$

The current at any time t is

$$i=\frac{e^{\frac{-Rt}{2L}}2EC}{\sqrt{4LC-C^2R^2}}\sin\left(\frac{\sqrt{4LC-C^2R^2}}{2CL}\right)t \tag{10}$$

From equation 8

$$\frac{2CL}{\sqrt{4LC-C^2R^2}}=\frac{T}{\pi}$$

a known value as T can be scaled from the oscillogram.

Also

$$\frac{2CE}{\sqrt{4LC-C^2R^2}}=\frac{ET}{\pi L}$$

and from equation 9

$$-\frac{Rt}{2L}=\frac{t\log\delta}{t_2-t_1}=\frac{t\log\delta}{T}$$

Substituting into equation 10

$$=e^{\frac{t\log\delta}{T}}\frac{ET}{\pi L}\sin\frac{\pi t}{T}$$

and then

$$L=e^{\frac{t\log\delta}{T}}\frac{ET}{\pi i}\sin\frac{\pi t}{T} \tag{11}$$

where i and t are corresponding values.

It is convenient to have $\sin \pi t/T$ equal unity. If L is known, then

$$R=\frac{-2L\log\delta}{T} \tag{12}$$

and

$$C=\frac{T^2}{\pi^2L+\left(\frac{RT}{2\sqrt{L}}\right)^2} \tag{13}$$

If in equation 11 t is taken as $T/2$ and used as t_1 with i_1,

$$L=\frac{ET}{\pi i_1}e^{\frac{1}{2}\log\frac{i_2}{i_1}} \tag{14}$$

The ratio i_2/i_1 must be taken positive, and the exponent of ϵ must be negative. For the critical case,

$$R^2=\frac{4L}{C}$$

and the current is

$$i=\frac{E}{L}t\epsilon^{\frac{-Rt}{2L}} \tag{15}$$

$$\frac{di}{dt}=\frac{-REt}{2L^2}\epsilon^{\frac{-Rt}{2L}}+\frac{E}{L}\epsilon^{\frac{-Rt}{2L}}$$

which at $t=0$ becomes E/L. Hence, the slope of the curve of an oscillogram, at $t=0$, similar to Figure 5, can be equated to E/L and, with E known, solved for L. However, the slope at $t=0$ is likely to be very uncertain, so measure i_1 and i_2 at t_1 and t_2 and substitute into equation 15. The ratio is

$$\frac{i_1}{i_2}=\frac{t_1}{t_2}\epsilon^{\frac{R}{2L}(t_1-t_2)} \tag{16}$$

so

$$\log_e\frac{i_1t_2}{i_2t_1}=\frac{R}{2L}(t_2-t_1)$$

and

$$\frac{Rt}{2L}=\frac{t}{t_2-t_1}\log_e\frac{i_1t_2}{i_2t_1} \tag{17}$$

This into equation 15 yields

$$L=\frac{Et}{i}\epsilon^{\frac{-t}{t_2-t_1}\log\frac{i_1t_2}{i_2t_1}} \tag{18}$$

where t and i are corresponding values. If these are identical with t_1 and i_1, then

$$L=\frac{Et_1}{i_1}\epsilon^{\frac{-t_1}{t_2-t_1}\log\frac{i_1t_2}{i_2t_1}} \tag{19}$$

and

$\frac{i_1t_2}{i_2t_1}$ is a positive fraction.

So from equation 16

$$R=\frac{-2L}{t}\log_e\frac{iL}{Et}$$

where i and t are corresponding values. Finally $C=4L/R^2$.

The oscillogram for a logarithmic case has the form of Figure 6. With a constant impressed voltage

$$Ri+L\frac{di}{dt}+\frac{q}{C}=E \tag{20}$$

where

$$q=\int_0^t idt$$

and is the charge in the capacitor at the instant t, starting with zero charge at $t=0$. If the oscillogram is of such form that the time t' can be found for maximum current at which $di/dt=0$, equation 20 can be written

$$Ri_{\max}+\frac{q'}{C}=E$$

where

$$q'=\int_0^{t'}idt=S'$$

the evaluated area under the curve from $t=0$ to $t=t'$. Hence

$$C=\frac{S'}{E-Ri_{\max}} \tag{21}$$

At another time t_2 with

$$S_2=\int_0^{t_2}idt \qquad \frac{S_2}{C}=E-Ri_2-L\frac{di_2}{dt} \tag{22}$$

If equation 20 is evaluated at $t=0$, it is

$$di/dt=E/L \tag{23}$$

So if the slope at $t=0$ can be evaluated,

$$L=\frac{E}{di/dt} \tag{24}$$

By rewriting equations 21 and 22

$$CE-CRi_1=S_1$$

and dividing equation 21 by 22

$$CE-CRi_2-CL\frac{di_2}{dt}=S_2$$

$$R=\frac{E(S_1-S_2)-LS_1\frac{di_2}{dt}}{i_2S_1-i_1S_2} \tag{25}$$

which with equation 21 gives C.

However, evaluation at $t=0$ may not be satisfactory.

In equation 20 let t have the values t_1, t_2, and t_3 with the corresponding slopes di_1/dt, di_2/dt, and di_3/dt and corresponding areas under the curve of S_1, S_2, and S_3. If these are substituted into equation 20 and the resulting equations solved, there results

$$L=\frac{E[(i_2-i_1)(S_2i_3-S_3i_2)-(i_3-i_2)(S_1i_2-S_2i_1)]}{i_2\left[\frac{di_1}{dt}(S_2i_3-S_3i_2)+\frac{di_2}{dt}(S_3i_1-S_1i_3)+\frac{di_3}{dt}(S_1i_2-S_2i_1)\right]} \tag{26}$$

where the currents are of positive sign but the rates are negative. Let this value of L be L_0, substitute this into equation 20 for the values of time t_2 and t_3, and solve,

$$R=\frac{E(S_3-S_2)+L_0\left(S_2\frac{di_3}{dt}-S_3\frac{di_2}{dt}\right)}{S_3i_2-S_2i_3} \tag{27}$$

and if this value of R be R_0, then

$$C=\frac{S_3}{E-i_3R_0-L_0\frac{di_3}{dt}} \tag{28}$$

To test these formulas oscillograms were supplied by Professor B. K. Osborn of Michigan State College. These were taken on a style S011D370 Westinghouse oscillograph. Blueprints were made and given to a class of 25 students to measure and to evaluate the factors R, L, and C. The results show that, notwithstanding distortion of the film and of the prints and the errors inherent in the measurement of slopes and areas, the accuracy was good when the average of several determinations was taken. Resistances were found to one half of one per cent, inductances to three per cent, and capacitances to one and one half per cent accuracy when compared with the results of the usual laboratory methods of measurement. Artificial oscillograms plotted from computed data and analyzed by these methods produced exact checks on the assumed circuit factors.

Under proper conditions evaluation of an oscillogram may show changes in the circuit factors. The effective resistance of a circuit may change with di/dt which is related to frequency. The method permits testing of the oscillograph itself. An oscillogram taken on a circuit of known constants should analyze into those same constants, and, if it does not, adjustments should be made. Records were found to be very sensitive to the degree of damping.

L. S. FOLTZ (M '25)

(Professor and head of electrical engineering department, Michigan State College, East Lansing, Mich.)

AIEE Member Runs for Congress

To the Editor:

It was not my intention to become a politician. The honor was thrust upon me. I'm a candidate for Member of Congress, 10th Congressional District, Kings County, N. Y., and I'm writing to all of my friends for their support. As a Member for Life of the AIEE, I feel that the membership of the Institute would be interested in my behalf.

My district comprises Stuyvesant Heights, Bedford District, and Flatbush bounded at one end by Ralph Avenue and on the other by Flatlands Avenue.

VIC WICHUM (A '07, M '37)

(Recently a major in the Ordnance Department, Army of the United States, and formerly chief engineer, C. J. Tagliabue Company, Brooklyn, N. Y.)

NEW BOOKS . . . .

"Aircraft Electricity for the Mechanic." Though this manual was prepared primarily for men handling aircraft who are not electrical engineers, the author also had in mind electrical engineers who are not concerned specifically with aircraft. Before it was printed, the manuscript was

used by the author in teaching aircraft electric and ignition systems to officers and enlisted men of the Army, Navy, and Marine Corps, as well as civilian students who were being trained to become pilots, maintenance supervisors, and mechanics. It is written so that it can be used in preparing for promotion examinations in the armed services and for examinations given by the Civil Aeronautics Administration to applicants for licenses as aircraft mechanics and aircraft engine mechanics. The fundamentals of electricity and of the aircraft electric system and its operation, maintenance, and inspection are explained. The most common troubles encountered in actual operation, their possible causes, the symptoms by which they are recognized, and the solutions for these problems are presented. Typical examination questions, a section on getting a job, and a comprehensive index are included. By Charles Edward Chapel. Coward McCann, Inc., New York, N. Y., 1946, $5^1/_4$ by $8^1/_4$ inches, cloth, 477 pages, $5.

"A Chronological History of Electrical Development." Commencing with the discovery of static electricity by the Greek, Thales, in 600 B.C., and continuing through several listings for 1944, this history records in brief paragraphs the pertinent facts about the first known accounts of theories, research, experiments, discoveries, and inventions contributing to present electrical knowledge. Dates of other historic occasions—electrical expositions, and congresses; the birth of electrical publications, engineering and trade association, societies, foundations, and institutes—also are given. The book is intended as a reference work for editors, writers, commentators, libraries, and schools, as well as for industry. An appendix giving the present and original names, the founder, and date of founding of the chief electrical companies in the United States is included. National Electrical Manufacturers Association, New York 17, N. Y., 1946, 6 by $9^1/_4$ inches, 106 pages plus appendix, cloth, $2.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

PHOTOGRAPHY IN ENGINEERING. By C. H. S. Tupholme. Faber and Faber Ltd. and the Hyperion Press Ltd., London, England, 1945. 276 pages, illustrated, $9^1/_2$ by 7 inches, cloth, 42*s*. The ways in which the camera is being used to simplify the draftsman's work, to analyze raw materials, to make records of high-speed machinery, in studying the molecular structure of metals, and in other ways are presented in this volume, which summarizes conveniently much scattered literature. Bibliographies provide for further study.

MANIFESTO FOR THE ATOMIC AGE. By V. Jordan. Rutgers University Press, New Brunswick, N. J., 1946. 70 pages, $7^1/_2$ by 5 inches, cloth, $1.50. The impact of the release of atomic energy upon the industrial and social framework of human life is assessed in the light of the current uncertain state of affairs. The results of previous revolutionary changes in the world situation are demonstrated, and a forecast of the likely shifts in the technological, economic, biological, and political aspects of human existence is presented.

ASTM STANDARDS. 1945 Supplement, including Tentatives. Part I. Metals. 397 pages. Part II. Nonmetallic Materials—Constructional. 229 pages. Part III. Nonmetallic Materials—General. 503 pages. American Society for Testing Materials, Philadelphia 2, Pa., 1945–1946, illustrated, $9^1/_2$ by 6 inches, cloth, $4 per part ($2.50 to ASTM members). This supplement to the 1944 book of ASTM Standards brings it up to date by giving all the changes or additions accepted during the year 1945. Two hundred and fifteen standards are included, some sixty of which appear for the first time. The supplement appears, like the original work in three volumes.

AMERICAN SOCIETY FOR TESTING MATERIALS, 1944 SUPPLEMENT TO THE BIBLIOGRAPHY AND ABSTRACTS ON ELECTRICAL CONTACTS. Prepared by Committee B-4 on Electrical-Heating, Electrical-Resistance and Electric-Furnace Alloys, American Society for Testing Materials, Philadelphia, Pa., 1945. 30 pages, 9 by 6 inches, paper. The original "Bibliography and Abstracts on Electrical Contacts," published in 1944, covered the period from 1835 to 1942. This first supplement contains some eighty items within that period which had not been included previously and carries on through 1943 into 1944. As before, an author and subject index are provided. A wide range of material is considered, and the abstracts are extensive enough for adequate determination of the particular value of the original articles.

ATOMIC AND FREE RADICAL REACTIONS. American Chemical Society Monograph Series 102. By E. W. R. Steacie. Reinhold Publishing Corporation, New York, N. Y., 1946. 548 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $8. The elementary reactions involving atoms and free radicals are of considerable importance in explaining the mechanism of thermal and photochemical reactions. This book brings together the existing data and discusses the kinetics of these elementary reactions. The material is restricted to reactions involving organic substances, mainly in the gaseous state. A reaction index and table of activation energies are included. Extensive reference to further material is made in footnotes.

ATOMIC ARTILLERY AND THE ATOMIC BOMB. By J. K. Robertson. D. Van Nostrand Company, New York, N. Y., 1945. 173 pages, illustrated, $7^1/_2$ by 5 inches, cloth, $2.50. In simple language, without mathematics, this book treats of the equivalence and interconversion of mass and energy, the meaning of nuclear fission and nuclear chain reactions, and the major details of construction of the plants for producing atomic power and atomic explosives. The early work on the passage of electricity through gases leads into the discussion of electrons and the heavier, faster types of particles so important in our newer fields of science, such as the release and control of atomic energy.

CAVENDISH LABORATORY. By A. Wood. University Press, Cambridge, England; The Macmillan Company, New York, N. Y., 1946. 59 pages, illustrated, $6^3/_4$ by 4 inches, cardboard, $1. In the 72 years since the Cavendish Laboratory was opened, it has become famous as a leader in physical developments. This book briefly describes the development of the laboratory under Clerk-Maxwell, Rayleigh, J. J. Thomson, and Rutherford and calls attention to some epoch-making results.

COURS D'ANALYSE INFINITÉSIMALE. Two volumes. By Ch.-J. de la Vallée Poussin. Volume 1, eighth edition, 460 pages; volume 2, seventh edition revised, 524 pages, 1946. Dover Publications, New York, N. Y., illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, $4 each (2 volumes, $7.50). This standard French text provides both a working knowledge of advanced calculus for the technical student and the basis for a thorough understanding of the fundamental principles of analysis for the student of mathematics. Volume I deals with the differentiation of implicit and explicit functions of one or more variables, with the classic methods of integration, and with the fundamental formulas of the theories of curves and surfaces. Volume II continues the work on various types of integrals, takes up differential equations and the calculi of variations and of finite differences, and goes thoroughly into the subject of geometrical applications.

THIN FILMS AND SURFACES. By W. Lewis Published for Temple Press, Ltd., by English Universities Press, Ltd., Little Paul's House, Warwick Square, London, England, 1946. 70 pages, illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, 15*s*. The structure of metal surfaces and of surface films (of oxide, and so forth) is considered first, with special reference to the structure of thin films. The production of thin metallic films next is dealt with, followed by a section discussing the mechanical, optical, magnetic, and electrical properties of metallic films and surfaces. The last two chapters collect what information is relevant about the properties of aluminum, briefly summarize some comparative data for other metals, and refer to some of the interesting applications of aluminum films and surfaces.

PRINCIPLES OF BUSINESS ORGANIZATION. By W. R. Spriegel and E. C. Davies. Prentice-Hall, Inc., New York, N. Y., 1946. 564 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $6.35. The material presented in this book is divided into the following major sections: ownership and structural forms of a business enterprise; promotion and operation of an enterprise; financial considerations; accounts and records; the manufacturing function; the marketing function; personnel maintenance.

PRACTICAL OPTICS. By B. K. Johnson. Hatton Press, Ltd., London, England, 1943. 189 pages, illustrated, 9 by $5^1/_2$ inches, cloth, 15*s*. This small volume presents the practical application of optical principles. These principles are discussed in the first two chapters, with succeeding chapters dealing respectively with the three main types of optical instruments: telescopes, microscopes, and photographic lenses. A separate chapter is devoted to the working and testing of optical glass.

PERSONALITY AND ENGLISH IN TECHNICAL PERSONNEL. By P. B. McDonald. D. Van Nostrand Company, New York, N. Y., 1946. 424 pages, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.75. This book emphasizes the importance of developing a definite personality, an accurate command of English, and effective methods for presenting ideas, both written and verbal, with specific suggestions for improvement in these particulars.

OFFICE LIBRARY OF AN INDUSTRIAL RELATIONS EXECUTIVE. Prepared by H. Baker. Fifth edition. Princeton University, Princeton, N. J., 1946. 36 pages, 9 by 6 inches, paper, 50 cents. A considerable list of recommended books, pamphlets, and periodicals for the industrial relations executive is presented under the following general headings: general works; specific personnel problems and programs; trade unions and collective bargaining; labor legislation and administration; social insurance.

INDUSTRIAL ECONOMY AND LABOR CONTROL. By W. L. McNaughton. Golden State Publishers, Village Station, Los Angeles 24, Calif., 1945. 273 pages, illustrated, 8 by $5^1/_4$ inches, cloth, $3.25; paper, $2.75. Dealing chiefly with motion and time study, this book devotes the first two sections to discussion of the importance and purpose of their application in an industrial plant. The succeeding three sections take up the practical aspects of plant layout, time study and motion economy, including materials handling and tool positioning.

INDUCTION HEATING. By H. B. Osborn and others. American Society for Metals, Cleveland, Ohio, 1946. 172 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $3. Five lectures presented at the 1946 National Metal Congress are combined in this book. They deal respectively with: the principles and theory of high frequency heating; induction heating circuits and frequency generation; practical applications of the motor-generator type of induction heating (up to 10,000 cycles); practical applications of high frequency induction heating (100,000 cycles and up); and a comparison of induction heating with other methods of heat treating.

HIGH VACUUM TECHNIQUE. By J. Yarwood. Second edition revised, John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1945. 140 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $2.75. This book describes the basic theories, standard techniques, methods of measurement, and industrial applications of high vacuums, with explanations of the physical bases of the methods adopted. The latest developments in apparatus are introduced, important industrial processes are outlined, and considerable factual material is presented regarding the relevant properties and uses of materials encountered in all types of vacuum work.

GERMAN FOR THE SCIENTIST. By P. F. Wiener, with an introduction by E. N. da C. Andrade. First American edition with additional sections and foreword by P. Spoerri. Chemical Publishing Company, Brooklyn, N. Y., 1946. 238 pages, illustrated, $7^1/_2$ by 5 inches, cloth, $3.50. Following a brief introductory section on German grammar, the author presents passages taken from the literature of chemistry and physics. These passages have been chosen from books obtainable in English to allow the student to carry on with any subject matter of interest to him, and have been selected for their content of basic German scientific words. The final section contains the English translations of the German passages. There is a vocabulary.

ELEMENTARY WAVE MECHANICS. By W. Heitler. The Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1945. 136 pages, illustrated, $7^1/_2$ by 5 inches, cloth, $2.25. Beginning with chapters on the experimental basis of quantum mechanics and the derivation of the wave equation, the author proceeds to discuss the hydrogen atom, angular momentum and spin, the problem of two electrons, perturbation theory, and the periodic system of elements. The last two chapters provide an introduction to the theory of chemical bond.

MÉTROLOGIE GÉNÉRALE. By M. Denis-Papin and J. Vallot. Dunod, Paris, France, 1946. 428 pages, illustrated, 6 by 4 inches, fabrikoid, 240 francs. This comprehensive manual covers the field of measurement from a broad point of view. Early chapters are devoted to a discussion of measurement in general, the international system of weights and measures, and the symbols and equations of fundamental systems of measurement. Methods of measurement and units are described for the fields of geometry, geography, mechanics, angular measure, stresses, electricity, and magnetism, heat and radiant energy, optics and time. Special industries, ancient and foreign units are covered.

INSTRUMENTS AND PROCESS CONTROL. New York State Vocational and Practical Arts Association, Albany, N. Y.; distributed by Delmar Publishers, Inc., Albany 6, N. Y., 1945. 233 pages, illustrated, 11 by $8^1/_2$ inches, paper, ring binder, $2.75. The general principles of process control are discussed, and a large number of instruments for specific control operations are described and illustrated. Mechanical, electrical, hydraulic and pneumatic control methods are included, and the name of the manufacturer is given for each instrument shown.

INDUSTRIAL RESEARCH 1946. Advisory Editor, E. N. da C. Andrade. Todd Publishing Company, London, England, and New York, N. Y. Sole British Distributors: George G. Harrap and Company, Ltd., 1946. 736 pages, 9 by $5^1/_2$ inches, cloth, $6. This British reference book presents first some 30 brief articles by specialists on various aspects—technical, educational, financial—of the important fields of industrial research. Succeeding sections contain classified directories of official trade and technical research organizations in Great Britain, and also lists of university and industrial research laboratories. A section discussing careers in industrial research includes courses available in universities and membership requirements for technical societies.

INDUSTRIAL RELATIONS AND THE SOCIAL ORDER. By W. E. Moore. Macmillan Company, New York, N. Y., 1946. 555 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, cloth, $4. Intended to supplement the standard treatments of industrial organization and relations, this book emphasizes the viewpoint of modern industry as a complex social organization. Following a discussion of the development of modern industry, come sections dealing with management and managerial functions, the sources and effective use of labor, and industrial relations. The final part discusses the interrelation of industry and society in general, including economic planning.

AMINOPLASTES. By P. Talet. Préface by J. Duclaux. Dunod, Paris, France, 1946. 235 pages, illustrated, 9 by $5^1/_2$ inches, paper, 280 francs. Following a statement of the general theory comes a brief description of the raw materials, urea and formaldehyde. The methods of formation are dealt with, covering the condensation, dehydration, and hardening processes. The preparation of molding powders and the methods of molding are treated in some detail. Several brief chapters take up such uses, as coatings and impregnation. Finally, some 50 pages are devoted to various modifications: the replacement of urea by other nitrogen compounds, for example, and similar treatments.

ATOMIC ENERGY IN COSMIC AND HUMAN LIFE. By G. Gamow. University Press, Cambridge, England; Macmillan Company, New York, N. Y., 1946. 161 pages, illustrated, $8^1/_4$ by $5^1/_4$ inches, cloth, $3. In the first section the author takes up the question of what atomic energy is and describes how atomic transformations are brought about. In the second section he describes the way in which these transformations are used by and produced in the stars. The final section discusses the problem of how man can use atomic energy, utilizing the method of neutron multiplication and bombardment as described.

BASIC MATHEMATICS FOR RADIO STUDENTS. By F. M. Colebrook. Wireless World. Iliffe and Sons, Ltd., London, England, 1946. 270 pages, illustrated, 7 by $4^1/_4$ inches, cloth, 10*s*.6*d*. The author's intent is to give the student a thorough groundwork in the basic ideas of elementary mathematics rather than a condensed statement of rules and formulas. The topics covered include algebra-indexes and logarithms, equations and complex numbers, limits and series, geometry, trigonometry, and differential and integral calculus. These chapters are all quite general, and suitable for any scientific or technical student. The special treatment appears only in the last chapter on the application of mathematical ideas to radio.

CORROSION OF METALS. By C. W. Borgmann, C. P. Larrabee, W. O. Binder, H. L. Burghoff, and E. H. Dix, Jr. American Society for Metals, Cleveland, Ohio, 1946. 181 pages, illustrated, $9^1/_4$ by 6 inches, fabrikoid, $3. In this small volume are reprinted five lectures presented at the 1946 National Metal Congress. The titles are: basic principles of metallic corrosion, effect of composition and environment on corrosion of iron and steel, corrosion resistance of stainless steels and high nickel alloys, copper and copper alloys in corrosive environments and corrosion of light metals.

DIESEL-ELECTRIC LOCOMOTIVE. By C. F. Foell and M. E. Thompson. Diesel Publications, New York, N. Y., 1946. 688 pages, illustrated, $9^1/_4$ by 6 inches, cloth, $7, United States; $8, elsewhere. The early chapters of this book cover the history, development, advantages, and classification of Diesel-electric locomotives. The remainder of the book deals with the constructional, engineering, operational, and maintenance aspects of the subject. Two chapters of general engineering fundamentals are included, and Diesel-hydraulic and Diesel-mechanical locomotives are given brief consideration.

ELECTRICAL ENGINEERING PROBLEMS. By W. Glendinning, 5123 Bell Boulevard, Bayside, N. Y., 1946. 112 pages, illustrated, $8^3/_4$ by $11^1/_2$ inches, paper, $3. This manual provides questions and solutions to the electrical engineering problems of 15 past examinations in professional engineering—Part III, Electrical Engineering, Group D—given to applicants for the license of professional engineer in New York State. Useful in preparing for professional engineering and civil service examinations, the material covers various types of problems in d-c and a-c machinery and in power and communication systems.

ELECTRON AND NUCLEAR COUNTERS. By S. A. Korff. D. Van Nostrand Company, New York, N. Y., 1946. 212 pages, illustrated, $8^3/_4$ by $5^1/_2$ inches, cloth, $3. This book first discusses the internal mechanism of the discharge in electron and nuclear counters. It then presents the constructional and operational features which are desirable and the best means for securing them, with discussion of the errors and corrections encountered in using the devices. Finally, the various electronic circuits which are the essential auxiliaries to successful operation are considered in some detail. Selectively sensitive and other special counters are covered as well as the conventional Geiger type.

ELECTRONS, ATOMS, MOLECULES. By A. C. Crehore. Christopher Publishing House, Boston, Mass., 1946. 133 pages, illustrated, $8^1/_2$ by $5^1/_2$ inches, fabrikoid, $3.75. The author presents his basis for hypothesizing a stable atom, and demonstrates his point by the mathematical analysis of the phenomena of molecule formation, crystal structure, and so forth. Energy determinations resulting from thermochemical investigations are used to a considerable extent in developing the conceptions put forth.

PAMPHLETS • • •

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers

The Physically Handicapped Worker in Industry. By Gilbert Brighouse. California Institute of Technology, Pasadena 4, Calif., 54 pages, $2.

Maintenance of Industrial Electronic Equipment. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa., 30 pages, no charge.

New Products and Services. *New York Journal of Commerce*, 63 Park Row, New York 15, N. Y., 32 pages, 50 cents.

New Code Changes Show Progress in Branch Circuit Wiring (chart). United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y., no charge.

1945–46 Year Book. American Standards Association, 70 East 45th Street, New York 17, N. Y., no charge.

International Trade Handbook. Committee for Economic Development, 285 Madison Avenue, New York 17, N. Y., 50 cents.

The ABC's of Modern Plastics. Bakelite Corporation, 300 Madison Avenue, New York 17, N. Y., 35 pages, no charge.

Recommended Practices for Automotive Flash-Butt Welding. American Welding Society, 33 West 39th Street, New York 18, N. Y., 22 pages, 30 cents.

RFC Small Business Activities. Reconstruction Finance Corporation, Washington 25, D. C., 15 pages.

Report of Tests on Fires in Magnesium Castings. Factory Mutual Laboratories, 184 High Street, Boston 10, Mass., 11 pages, no charge.

Memorandum on Servomechanisms. G. C. Wilson and Company, P. O. Box 389, Chatham, N. J., no charge.

Your Place in the Sun. General Electric Company, Nela Park, Cleveland 12, Ohio, 23 pages, 10 cents.

Applications and Economics of the Diesel Engine. By Harvey T. Hill. Diesel Engine Manufacturers Association, 1 North La Salle Street, Chicago 2, Ill., 15 pages.

Airline Airport Design Recommendations. Part I. Airport Requirements, Airport Location, Classification of Airports, Aprons, Runway Clearances, Runway Configurations, 43 pages. Part IV. Airport Lighting, 33 pages. Air Transport Association of America, 1107 16th Street N. W., Washington 6, D. C.

Rod Selector Chart. Eutectic Welding Alloys Corporation, 40 Worth Street, New York 13, N. Y., no charge.